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Climate Change and Indigenous Peoples: A Synthesis of Current Impacts and Experiences

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Abstract

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A growing body of literature examines the vulnerability, risk, resilience, and adaptation of indigenous peoples to climate change. This synthesis of literature brings together research pertaining to the impacts of climate change on sovereignty, culture, health, and economies that are currently being experienced by Alaska Native and American Indian tribes and other indigenous communities in the United States. The knowledge and science of how climate change impacts are affecting indigenous peoples contributes to the development of policies, plans, and programs for adapting to climate change and reducing greenhouse gas emissions. This report defines and describes the key frameworks that inform indigenous understandings of climate change impacts and pathways for adaptation and mitigation, namely, tribal sovereignty and self-determination, culture and cultural identity, and indigenous community health indicators. It also provides a comprehensive synthesis of climate knowledge, science, and strategies that indigenous communities are exploring, as well as an understanding of the gaps in research on these issues. This literature synthesis is intended to make a contribution to future efforts such as the 4th National Climate Assessment, while serving as a resource for future research, tribal and agency climate initiatives, and policy development.

Keywords: climate change, indigenous, tribal, adaptation, traditional knowledge.

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Introduction

Climate change is affecting the culture, sovereignty, health, economies, and lifeways of indigenous peoples in the United States and affiliated territories (Bennett et al. 2014a, Maldonado et al. 2014, Parker et al. 2006). In the United States, there are 567 federally recognized American Indian and Alaska Native tribes, as well as state-recognized tribes, Native Hawaiian peoples, unrecognized tribes, and indigenous peoples of U.S.-affiliated territories living in remote, rural, and urban communities within the Nation. In this report, we use the term "tribe" and "indigenous people" interchangeably unless referencing a specific group or specific recognition status.

A growing body of literature examines the vulnerability, risk, resilience, and adaptive capacity of indigenous peoples to climate change. For example, the 3rd National Climate Assessment (NCA) released in 2014 devoted a chapter to the impacts of climate change on indigenous peoples, lands, and resources. Alaska Native and American Indian tribes and other indigenous communities in the United States are already observing and experiencing the impacts of climate change. Insights about how these impacts are affecting indigenous peoples can contribute to the development of policies, plans, and programs for adapting to climate change and reducing greenhouse gas (GHG) emissions.

This synthesis of literature brings together research pertaining to the impacts of climate change on indigenous sovereignty, culture, health, livelihoods, and economies that are currently being experienced by indigenous communities in the United States. This synthesis defines and describes the key frameworks informing indigenous understandings of climate-change impacts and strategies for adaptation and mitigation, namely tribal sovereignty and self-determination, culture and cultural identity, and indigenous community health indicators. The synthesis then focuses on the impact of climate change on various facets of indigenous community health.

The purpose of this report is to contribute to efforts of tribal leaders, scholars, and others working to strengthen indigenous self-determination by providing a synthesis of literature related to climate change and indigenous peoples in the United States. The synthesis focuses on the breadth of new literature on climate change and indigenous peoples (2012–2015), and includes references to earlier literature in discussions of tribal sovereignty, traditional knowledges, and tribal culture to provide appropriate context. It brings together new scholarship and provides a comprehensive synthesis of climate knowledge, science, and strategies that indigenous communities are exploring, as well as an understanding of the gaps in research on these issues. This literature synthesis is intended to make a contribution to future efforts such as the 4th NCA, while serving as a resource for future research, tribal and agency climate initiatives, and policy development.

Climate Impacts on Indigenous Peoples in the United States

American Indians and Alaska Natives are already experiencing the impacts of climate change (Bennett et al. 2014a, IPCC 2014). Although these impacts differ by region, there are commonalities in how climate change is experienced by indigenous communities across the United States. For tribes in coastal areas, erosion and sea-level rise threaten vital community infrastructure and are leading to forced displacement and relocation (Callaway et al. 1999, CLTC 2012). For tribes in the Pacific Northwest and California, changes in streamflow and water temperature will increase the severity of existing declines in salmon and other culturally important species (Jenni et al. 2014, Montag et al. 2014). For tribes in the Southwestern United States, reductions in rainfall and the continued experiences of prolonged drought affect soil quality and ranching and agricultural practices (Cozzetto et al. 2013a, 2013b; Redsteer et al. in press, 2013a).

Climate impacts include reduced access to culturally important habitats, places, and species.

Tribes across the United States are experiencing reductions in access to culturally important habitats and species. In Alaska, permafrost melting is making it more difficult for hunters to access traditional hunting grounds and is changing the migration patterns of certain species. In the Pacific Northwest, changes in the temperature and flow of water are exacerbating existing stresses on salmon and shellfish populations, which are vital to the economic, spiritual, and cultural health of communities. In the Southwest, the influx of invasive species and prolonged drought are disrupting subsistence practices. These impacts threaten traditional knowledges, food security, water availability, historical homelands, and territorial existence, and may undermine indigenous ways of life that have persisted and adapted for thousands of years.

The vulnerability of some indigenous communities to climate change is based on cultural, social, and economic dependence on local species, habitats, and ecosystems, as well as legal, social, and political contexts of colonialism, institutionalized racism, and forced relocation (Kronk Warner 2015a; Lynn et al. 2013; Maldonado et al. 2014; Marino 2012, 2015; Whyte 2013; Williams and Hardison 2013). As noted by Marino (2015: 96), vulnerability is not characteristic of a community, but the product of systems of inequality. Tribes differ in their vulnerability to climate change based on their distinct cultural practices and economies, and the vulnerability of indigenous sociopolitical, economic, and ecocultural systems may differ by geography and climate regime. As Gautam et al. (2013) demonstrated, although tribes may face similarities in terms of how climate change may affect their socioeconomic status and dependence on natural resources, distinct cultural practices influence how climate change vulnerability is experienced. Despite this variability, similarities among indigenous communities may exist in terms of the institutional

barriers—including legal, administrative, and congressional policies—that affect adaptation and resilience among tribes. Federal policies may have unintended consequences of limiting or removing climate adaptation options and in turn constraining, restricting, and undermining adaptation efforts within indigenous communities (Nakashima et al. 2012). For example, resource management or conservation policy that does not fulfill legal requirements for formal tribal consultation may inadvertently limit tribal access to culturally important resources important for tribal adaptation (Lynn 2011, Lynn et al. 2013).

Climate-change adaptation refers to preparing for, responding to, and coping with the effects of climate change. Although adaptation is not a new experience for indigenous peoples, climate change may threaten what Whyte (2013: 518) called "collective continuance," or a "community's capacity to be adaptive in ways sufficient for the livelihoods of its members to flourish into the future." Indigenous peoples experience social and political inequalities that may severely limit adaptive capacity. Many indigenous communities in the United States face extreme poverty, as well as inadequate housing, infrastructure, health and educational services, and other socioeconomic factors that will compound the impacts of climate change. Additionally, depending on their legal and political status, indigenous communities have different access and authority to implement adaptation strategies at meaningful scales—both locally and nationally. The impacts of climate change occur within a web of historical and contemporary oppressions, diverse political and legal statuses, and limited economic resources.

Indigenous vulnerability and resilience to climate change cannot be detached from the context of colonialism, which created both the economic conditions for anthropogenic climate change and the social conditions that limit indigenous resistance and resilience capacity (Cameron 2012, Marino 2015, Whyte 2016, Wilson 2014). As was asserted by Cameron (2012: 104):

> Climate change itself…is thoroughly tied to colonial practices, both historically and in the present, insofar as greenhouse gas production over the last two centuries hinged on the dispossession of indigenous lands and resources.

As a result of colonialism, many of the traditional adaptation practices that allowed indigenous communities to endure environmental changes are no longer possible. Through the examination of subsistence practices in the Koyukon Athabascan village of Ruby, Alaska, Wilson (2014) demonstrated how social changes resulting from European contact and colonization, such as increased sedentarization (loss of mobility), contact and compliance with the Western market economy, and creation and enforcement of governmental subsistence harvesting regulations, shape

the vulnerability to climate impacts by constraining efforts to respond to ecological change. Therefore, climate-change adaptation is not only about responding to observable impacts of climate change, "it is also about understanding and addressing the manner in which the broader political context can make communities more or less vulnerable to the impacts of climate change" (Wilson 2014: 97).

Resistance—typically used in an ecological context, but applicable to sociocultural systems—is described as practices that improve or strengthen defenses against the direct and indirect effects of climate-change-related impacts (Millar et al. 2007, Schlosberg and Carruthers 2010, Whyte 2013). Resistance is another facet of the political, social, and cultural capacity to address and confront threats and stressors. Indigenous peoples have to confront the inadequacy of existing federal policies and influence legislation to change or develop applicable policy. Indigenous social systems have to withstand external and internal challenges to maintain strong governance and traditional leadership structures to confront climate-related impacts.

Although climate change is affecting indigenous cultures and ways of life, indigenous communities are extremely resilient (Bennett et al. 2014b, Nakashima et al. 2012, Wildcat 2009). The Intergovernmental Panel on Climate Change (IPCC) (2007: 880) defined resilience as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change." Although indigenous resilience does not eliminate the consequences of colonialism or climate-change impacts, it does demonstrate the ability of indigenous populations to examine impacts and develop strategies for addressing and adapting to climate change. This resilience is embedded in traditional knowledges, diverse livelihoods, cultural values, and social networks that contribute to indigenous adaptive capacity (Chief et al. 2014, Nakashima et al. 2012).

Recent science, media, and academic literature illustrate the severe and disproportionate impacts of climate change on indigenous peoples (Bennett et al. 2014a, IPCC 2014, Maldonado et al. 2014). This labeling of tribes as vulnerable can "imply a lack of agency and competence," recreating racist stereotypes of tribes "needing the help of white outsiders" (Marino 2015: 29). And yet, indigenous communities are leading efforts to engage in climate-change adaptation and mitigation at regional, national, and international levels (Hansen 2013). Indigenous understandings and actions to address climate change are rooted in indigenous knowledges that are as diverse as the communities and ecosystems from which they emerge (Cochran et al. 2013).

Framework for Understanding Climate Impacts on Indigenous Peoples

In this report, we first consider three frameworks for understanding how climate change affects indigenous peoples. These frameworks represent the historical context(s) of indigenous populations that shape their vulnerability and potential pathways for addressing climate-change adaptation and mitigation. In this section, we consider specifically tribal sovereignty and self-determination, traditional knowledges and culture, and community health. These frameworks are intended to allow for an indigenous-centered perspective on the assessment, adaptation, and mitigation of climate-change impacts.

Tribal Sovereignty and Self-Determination

The U.S. federal government interacts with federally recognized tribes as sovereign nations through treaties, policies, and statutes (Galanda 2010). Prior to the formation of the federal government, tribal nations entered into treaties with Great Britain and other European nations (Allen 1989). From 1778 to 1871, during the "treaty making era," the federal government continued this treaty-making relationship, ratifying nearly 400 treaties and leaving many other negotiated treaties unratified. Between 1823 and 1832, three Supreme Court cases, known as the Marshall trilogy, established tribes as domestic dependent nations that govern themselves under the protection of the federal government (Allen 1989, Goodman 2000). As sovereign governments, federally recognized tribes retain inherent sovereign power and exercise authority over members, activities, and lands in many circumstances. Tribal sovereignty refers to the right of federally recognized tribes to govern themselves, define membership, protect cultural resources, control economic activity, and manage tribal land and resources. Tribal sovereignty also recognizes the existence of a government-to-government relationship between federally recognized tribes and the federal government (Galanda 2010, Goodman 2000, Redsteer et al. 2013a).

The federal government's responsibility to protect tribal nations is now understood as the federal trust responsibility (Redsteer et al. 2013a). This general, moral trust responsibility includes a fiduciary obligation to protect treaty rights, lands, assets, and resources (Allen 1989). This trust responsibility is administered by the Bureau of Indian Affairs, but other agencies that control federal land and other natural resources must protect any applicable tribal rights, including water, fish, wildlife, and cultural resources (Gruenig et al. 2015, Redsteer et al. 2013a). The legal and political status of the federally recognized tribes requires that U.S. government agencies consult directly with tribal governments before taking actions that may affect tribal trust resources, cultural practices, or access to traditional areas of cultural or religious importance on federally managed lands (CTKW 2014).

The federal government has an obligation to protect treaty rights, lands, and resources.

Consultation obligations are found in several statues, as well as in Executive Order 13175 (2000), "Consultation and Coordination With Indian Tribal Governments," which requires federal agencies to "have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications" (EO 13175 2000: 5(a), Galanda 2010, Goodman 2000). In 2009, Secretarial Order 3289 § 5 ("Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources") established the role of the Department of the Interior (USDI) in working with tribes through USDI climate-change initiatives (Salazar 2009: 4):

> Climate change may disproportionately affect tribes and their lands because they are heavily dependent on their natural resources for economic and cultural identity. As the Department has the primary trust responsibility for the federal government for American Indians, Alaska Natives, and tribal lands and resources, the Department will ensure consistent and in-depth government-to-government consultation with tribes and Alaska Natives on the Department's climate change initiatives. Tribal values are critical to determining what is to be protected, why, and how to protect the interests of their communities. The Department will support the use of the best available science, including traditional ecological knowledge, in formulating policy pertaining to climate change. The Department will also support substantive participation by tribes in deliberations on climate-related mechanisms, agreements, rules and regulations.

Tribal sovereignty and self-determination are important to understanding the impacts of climate change on tribes (Abate and Kronk Warner 2013). As sovereign governments, federally recognized tribes have the authority to manage tribal lands and resources on reservations and within certain territorial jurisdictions (Galanda 2010, Goodman 2000). Based on varying history, land ownership, and jurisdiction, climate-change impacts will influence tribal sovereignty differently. Tribes without a reservation are unable to exercise regulatory jurisdiction in the same ways as those who possess a trust land base (Tsosie 2013). Many federally recognized tribes depend on treaty-reserved rights on nonindigenous federal lands to maintain traditional practices (Galanda 2010). Some federally recognized tribes were created by presidential executive order (for California tribes, see Heizer 1972), which limits off-reservation use of natural resources within a tribe's ancestral territory.

Tribes face many obstacles that may exacerbate climate-change impacts and complicate adaptation, including federal land management, limited tribal influence over management decisions, and the recognition of the rights of tribes to traditional off-reservation areas (Cozzetto et al. 2013a, Houser et al. 2001, Williams and

Hardison 2013). Federally recognized tribes within Indian country and with more control over tribal lands will have more power to implement climate policies and decisions regarding land and resource management than will federally recognized tribes without reservations or nonfederally recognized tribes. Tribes with fragmented reservation lands may be negatively affected if nontribal landowners contest climate policies or adaptation measures, and tribal access to usual and accustomed sites may be disrupted by impacts to culturally significant places and species. Lacking federal recognition, state-recognized and unrecognized tribes often lack the political power and governmental support to address climate-change impacts, leaving them as some of the most vulnerable to climate change (Maldonado 2014b, Middleton 2013, Tsosie 2013, Whyte 2016).

Tsosie (2013) differentiated between political sovereignty and cultural sovereignty. Although political sovereignty results from federal recognition, all indigenous communities, regardless of recognition, possess cultural "self-defined" sovereignty. This means that indigenous peoples experience the right to self-determination by maintaining their ways of life, a principle that can be used to protect indigenous rights to language, religion, and culture (see also Whyte 2013, Whyte in press).

> The political sovereignty of indigenous peoples under U.S. federal Indian law is grounded in a more ancient sovereignty, which is an "internal, cultural-and community based model of sovereignty that reflects the identity of Native peoples as the "first Nations" of the land. The concept of "cultural sovereignty" is a valuable basis for the construction of an indigenous right to self-determination because it is constructed from "within" Native societies, rather than from "outside" by the federal courts or Congress, struggling to determine the "limits" of inherent sovereignty (Tsosie 2013: 83).

Impacts to treaties and reserved rights—
Climate-change impacts occur across jurisdictional boundaries and may threaten treaty and rights on and off of reservations. Reservation, treaty, and other jurisdictions are based on fixed boundaries (Galanda 2010). As climate change alters landscapes and ecosystems, the habitat for treaty-protected species may shift outside boundaries or disappear, negatively affecting tribal treaty rights and subsistence, cultural, and economic practices (Voggesser et al. 2013). According to the Tulalip Natural Resources Department:

> For the tribes, range shifts in native species will threaten their cultural existence. The treaty-protected rights of tribes to hunt, fish, and gather traditional resources are based on reservation locations and usual and

> accustomed areas on public lands. These locations are chosen to ensure access to culturally significant resources, whose locations were thought to be fixed. If the traditionally significant plants, animals, and aquatic species shift out of these areas, tribes will no longer have the same legal rights to them (McNutt 2010: 8).

Subsistence rights and access to traditionally significant plants, animals, and aquatic species can be affected.

Food sovereignty is associated with indigenous peoples' subsistence rights and can also be affected by the effects of climate change (Dussias 2010). In the Pacific Northwest, where salmon are fundamentally important to tribal cultures, economies, and substance practices, treaty fishing rights were ratified to protect indigenous ways of life. However, the impacts of climate change on rainfall, river temperatures, and streamflow patterns are placing further stress on already declining salmon populations (Dittmer 2013, Montag et al. 2014, Osborn 2012). These and other impacts from climate change challenge the understanding of the federal government's legal obligations to the federal trust responsibility (Tsosie 2013, Williams and Hardison 2013, Whyte 2014). Knowledge of treaties and reserved rights is important in understanding the impact of climate change on federally recognized tribes (Gruenig et al. 2015, Redsteer et al. 2013a).

Although the federal government has repeatedly failed to uphold many treaties that it signed, enforcing treaty rights in a climate-change context may provide a legal tool to enforce treaty rights and protect tribal resources threatened by climate change (Kronk Warner 2015a). Kronk Warner (2015a) used examples from the Swinomish and Nez Perce Tribes to demonstrate how the language of treaties may be useful in protecting resources. It is important that treaty provisions be interpreted as they were originally understood and agreed to by the tribes. The significance of natural and cultural resources such as fish and wildlife suggests that tribes assumed the permanent existence of these resources. Tribes may argue successfully that the federal government is obligated to take additional measures to protect fish if the tribe proves that the government's actions (or inaction) are interfering with the availability of treaty-guaranteed fish (Kronk Warner 2015a).

Loss of tribal land and access to resources—
For many indigenous communities, natural resources have cultural, economic, traditional, and recreational value. However, the very classification of practices in this way reflects colonial, not indigenous, culture (see Burger et al. 2008). The effects of climate change on terrestrial, marine, and freshwater resources affect tribal traditions, access to culturally important habitats with valued plants and animal species, tribal sovereignty, federal policies, and the federal trust responsibility. Landscape and climate contribute to a vital sense of place that is important to the culture and progeny of indigenous communities (Maynard 2014, Wildcat 2009).

Climate-change-related impacts are causing loss of tribal land and access to culturally important resources such as sacred sites, plant and animal species, water, and traditional homelands (Carothers et al. 2014, Cozzetto et al. 2013a, Lynn et al. 2013, Voggesser et al. 2013). The rights of tribes as they are acknowledged by the federal government exist within specific boundaries, including reservations and usual and accustomed areas. Williams and Hardison (2005: 10) asserted that "moving from these lands to adapt to large-scale environmental decline would cut them [tribes] off from their origins, the places of their collective memory, and the rights to self-determination the tribes possess as people." This is a central concern for coastal tribes facing relocation (Bennett et al. 2014a; Maldonado 2014a, 2014b). There is a very high likelihood that coastal erosion, sea-level rise, melting permafrost, or extreme weather events will force many coastal tribal communities to relocate (Bennett et al. 2014a), with potentially detrimental impacts on indigenous communities, culture, health, and economic well-being.

Indigenous communities that are vulnerable to displacement face the difficult task of ensuring that their communities will be able to stay in place for as long as possible. If the community decides that it is too vulnerable to adapt in place, community leaders may make the difficult decision to relocate (Peterson and Maldonado 2016). Three coastal Alaska Native Villages—Newtok, Kivalina, and Shishmaref—have lost basic necessities and infrastructure to accelerated erosion caused by thawing permafrost, decreasing extent of Arctic sea ice, and increasing numbers of extreme weather events (Brubaker et al. 2015, Cochran et al. 2013, Maldonado et al. 2013). Similarly, some coastal tribal communities in Louisiana are facing threats of displacement as a result of the interaction between environmental changes, such as sea-level rise, saltwater intrusion, and extreme weather, and politically and economically driven environmental degradation, such as oil- and dam-related development (Maldonado 2014b, Peterson and Maldonado in press). As we later discuss, this contemporary vulnerability is shaped in part by legacies of colonialism that limit the implementation of traditional adaptation strategies (Marino 2012, 2015; Wilson 2014).

Communities that decide to relocate are often not equipped with the funding and support required for relocation (Marino 2015) and may be excluded from funding for existing infrastructure in their current location (Peterson and Maldonado in press). Once they decided to relocate, the Alaska Native villages of Newtok and Shishmaref were cut off from state and federal infrastructure funding (Peterson and Maldonado in press). How tribal and indigenous communities forced to relocate will maintain community and culture is a key question addressed in the literature.

Currently, the federal government is ill-equipped to deal with the realities of climate-induced relocation and lacks applicable policy with directives for an institutional framework to relocate indigenous communities. In addition, tribal governments do not have the legal authority or the technical, organizational, or financial abilities to implement relocation programs (Maldonado 2014a).

Opportunities for self-governance and self-determination—Tribal-sovereignty and self-determination must be supported in climate-change initiatives (Gruenig et al. 2015). The right to indigenous self-governance and self-determination has been acknowledged by the federal government through its 2010 endorsement of the U.N. Declaration on the Rights of Indigenous Peoples (UNDRIP 2007), which recognizes the rights of indigenous peoples worldwide to self-determination and self-governance (Gruenig et al. 2015).

> Article 3: "Indigenous people have the right to self-determination. By the virtue of that right, they freely determine their political status and freely pursue their economic, social, and cultural development" (UNDRIP 2007: 4).
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> Article 4: "Indigenous people, in exercising their right to self-determination, have the right to autonomy or self-government in matters relating to their internal and local affairs, as well as ways and means for financing their autonomous functions" (UNDRIP 2007: 7).
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> Article 24**:** 1. "Indigenous peoples have the right to their traditional medicines and to maintain their health practices, including the conservation of their vital medicinal plants, animals and minerals. Indigenous individuals also have the right to access, without any discrimination, all social and health services" (UNDRIP 2007: 9).
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> Article 25**:** "Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard" (UNDRIP 2007: 10).
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> Article 29**:** "Indigenous peoples have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources. States shall establish and implement assistance programmes for indigenous peoples for such conservation and protection, without discrimination" (UNDRIP 2007: 11).

Under international law, the U.S. government has the responsibility not to undermine the principles of the UNDRIP (Gruenig et al. 2015).

Self-governance and tribal sovereignty are associated with the management of tribal lands. Federally recognized tribes have the right to manage resources on reservations and within other jurisdictional boundaries (Goodman 2000, Gruenig et al. 2015). Many federally recognized tribes are managing programs related to climate change, including environmental monitoring and climate-change mitigation and adaptation strategies. Tribes use traditional knowledges and tribal-led scientific research to support policies and decisions (Gruenig et al. 2015).

To further focus on tribal sovereignty and self-determination in the context of climate change, Whyte (2013: 517) encouraged policymakers, scientists, and professionals working on climate adaptation to rely on a framework that "situates justice within the systems of responsibilities that matter to tribes and many others, which range from webs of inter-species relationships to government-to-government partnerships." He argued that "justice is achieved when these systems of responsibilities operate in ways that support the continued flourishing of tribal communities."

As the benefits of traditional land management practices are recognized and implemented, tribes may have the opportunity to regain the management of historical homelands previously managed by the federal government (Wood 2014). Central concerns with the implementation of traditional land management are knowledge sovereignty and the protection of traditional knowledges. Some tribes are using tribal laws to protect traditional knowledge used in the context of climate change (Brewer and Kronk Warner 2015). The Karuk Tribe is working to employ traditional land management strategies by promoting knowledge sovereignty, tribal self-determination, and tribal self-governance (Norgaard 2014), exercised by entering into memoranda of understanding regarding areas of cultural significance occurring on federal lands (e.g., national forests) within Karuk ancestral territory (see Lake and Long 2014).

The protection of traditional knowledges and land-management practices have been central to conversations surrounding recent international climate-change mitigation programs like the United Nation's REDD+ (Reducing Emissions from Deforestation and Forest Degradation). REDD+ attempts to reduce greenhouse emissions through the conservation of forests in developing nations and the enhancement of forest carbon stocks, allowing developed nations to earn credits towards reducing emissions by paying to conserve forests in developing nations. Many of the targeted forests are home to indigenous peoples, who often lack the legal and political recognition to protect lands from governmental and nongovernmental entities seeking profit through the REDD+ program (Crippa and Gordon 2013). According to Crippa and Gordon (2013: 2):

> Protecting indigenous peoples' rights to their lands, territories, environment and natural resources, and strengthening indigenous peoples' capacity to effectively manage their territories, is a critical strategy for preventing deforestation and should be a central goal of climate mechanisms, including REDD+. Unfortunately, many REDD+ initiatives instead seek to "conserve the forest from indigenous peoples" — restricting their access to their own land, territories and resources, expropriating their land, commodifying their environments, and criminalizing their traditional livelihoods. More often than not REDD+ has become synonymous with violations of indigenous peoples' basic human rights and disruption of their livelihoods.

Indigenous people around the world have expressed concerns about climate-change impacts and have worked to become part of the global dialogue. However, concerns remain about whether indigenous voices in the United States will be acknowledged in climate negotiations that will determine how REDD+ is implemented, and whether adaptation options will consider threats to culturally relevant species and sacred sites. Critics are concerned that the program will facilitate a land grab of indigenous forests (Crippa and Gordon 2013, Holmes and Potvin 2014, Larson et al. 2013). REDD+ presents an example of how adaptation measures can harm indigenous peoples through the process of maladaptation (discussed further in "Tribal Approaches to Climate Change: Adaptation and Mitigation.")

Climate Change and Tribal Culture

For indigenous communities, climate change can result in loss of cultural identity through loss of place and ways of life. For many indigenous communities, culture and cultural identity are emergent from landscape and based on relationships of reciprocity with animals, plants, fungi, and ecosystems (Anderson 2005, Whyte 2013, Wildcat 2009). The loss of place results in the loss of both ways of life and right to collective self-determination. Loss of ways of life occurs when environmental changes challenge the viability of cultural practices and thus cultural identity (Maynard 2014, Wildcat 2009). The IPCC, NCA, and other studies and publications have discussed the potential for climate change to shift species migration patterns; change the geomorphology of rivers, sea ice, and coastal areas; and lead to unpredictable precipitation and extreme weather events (Maldonado et al. 2013). Indigenous communities have struggled to maintain their cultural identity and cultural practices through initial and ongoing periods of colonialism, genocide, and forced assimilation. This history has provided many indigenous communities with valuable adaptation experience to inform climate-change adaptation, resilience, and resistance. As cultures continue to be threatened by climate-induced

environmental changes, indigenous peoples ground resilience, resistance, and adaptation strategies in traditional knowledges and tribal sovereignty (Chief et al. 2014, Cochran et al. 2013).

Traditional knowledges—
The term "traditional knowledges" refers to both individual pieces of information and the traditional "knowledge systems" embedded in indigenous ways of life (CTKW 2014). Traditional knowledges emerge from reciprocal relationships between indigenous peoples and place, or what the *Guidelines for Considering Traditional Knowledges in Climate Change Initiatives* (CTKW 2014: 1) refer to as a "nature-culture nexus." Therefore, indigenous communities and knowledge holders have unique ways of knowing, experiencing, understanding and practicing traditional knowledges. These dynamic and diverse knowledges and knowledge systems share common dimensions represented by the term **traditional knowledges** (Houde 2007). As explained by the *Guidelines for Considering Traditional Knowledge in Climate Change Initiatives* (CTKW 2014: 7):

> [Traditional knowledges] broadly refer to indigenous communities' ways of knowing that both guide and result from their communities members' close relationships with and responsibilities towards the landscapes, waterscapes, plants, and animals that are vital to the flourishing of indigenous cultures.

Traditional knowledges can encompass culture, experiences, resources, environment, and animal knowledge (Schuler 2013); are accumulated through "experience, relationships, and upheld responsibilities towards other living beings and places" (CTKW 2014: 7); and are passed down generationally from elder to youth through oral histories, stories, ceremonies, and land management practices (CTKW 2014, Schuler 2013). These traditional knowledges are considered by many to be a gift and come with certain responsibilities, such as determining when and with whom they should be shared (CTKW 2014).

Ways of knowing, encompassing culture, experiences, resources, environment, and animal knowledge, and passed down from elder to youth through oral histories, stories, ceremonies, and land management practices, are collectively referred to as traditional knowledges.

Traditional knowledges and climate change—
Traditional knowledges are fundamental to indigenous understandings of climate change, for resistance activities, and to resilience and adaptation to climate change, inspiring what Wildcat (2009) called "indigenuity." Indigenuity—indigenous ingenuity—is "the ability to solve pressing life issues facing humankind now by situating our solutions in Earth-based local indigenous deep spatial knowledge" (Wildcat 2009: 48).

Traditional knowledges inform tribal understanding of climate impacts and environmental baselines while providing observational evidence, and informing culturally appropriate adaptation strategies (Adger et al. 2007, Cochran et al.

2013, Williams and Hardison 2013). Redsteer et al. (in press) demonstrated how the knowledge of Navajo elders can be used to gain more holistic understanding of the impacts of climate variation on semi-arid environments and to identify changes to soil moisture and species migration unavailable in most meteorological and streamflow data. Similarly, Wilson et al. (2015) showed how indigenous knowledges can contribute to the understanding of hydrologic change by (1) providing long-term data when Western scientific data is unavailable, (2) identifying new areas of inquiry by observing changes previously unidentified by Western science, and (3) being used in conjunction with Western methods across different scales.

Simultaneously, traditional knowledges are also vulnerable to the impacts of climate change (Whyte 2014). Traditional knowledges transform with changes in the landscape and may be degraded by rapid environmental change. Traditional knowledges may lose their ability to determine culturally appropriate times for ceremonies, plantings, and seasonal harvests (Cochran et al. 2013). Tribal cultural practices linked with phenological matches are occurring when subsistence practitioners and ceremonial leaders use species from different habitats, or with differential life history stages, to predict or plan activities. For example, in a presentation at the 3rd Annual Climate Change and Indigenous Peoples Conference, Paulette Blanchard described how the spring bread dance is traditionally held when a certain tree has leaves the size of a squirrel's ear. However, Blanchard elaborates that in recent years, the tree leaves have been in full bloom, much larger than squirrel's ears, leading her aunties to state, "If we are going to have bread dance, we are going to have squirrels with elephant ears" (Blanchard 2014).

Traditional knowledge in climate-change initiatives—
Recognition of traditional knowledges as a resource for climate change assessment and adaptation is growing among nonindigenous scientists, researchers, and policymakers (Brewer and Kronk Warner 2015, Cochran et al. 2013, Wildcat 2009). An IPCC report, Climate Change 2014: Impacts, Adaptation, and Vulnerability, asserted that:

> Indigenous local, and traditional knowledge systems and practices, including indigenous peoples' holistic view of community and environment, are a major resource for adaptation efforts. Integrating such forms of knowledge with existing practices increases the effectiveness of adaptation (IPCC 2014).

Incorporating indigenous and scientific perspectives on climate can result in climate assessments and adaptation strategies that are rooted in multiple ways of

knowing. The benefits of knowledge sharing in climate adaptation projects are exemplified in the report Weathering Uncertainty, which stated, "Community-based and local knowledge may offer valuable insights into environmental change due to climate change, and complement broader scale scientific research with local precision and nuance" (Nakashima et al. 2012: 6).

This topic was explored further in 2014 by the United Nations' Framework Convention on Climate Change (FCCC 2014) Subsidiary Body for Scientific and Technological Advice (SBSTA 2015). This group examined the use of traditional knowledges in adaptation practices, the needs of indigenous communities, and the application of gender-sensitive approaches to adaptation. According to the report, considering traditional knowledges in adaptation practices results in:

> More accepted and efficient adaptation activities. Adaptation activities developed in close collaboration between a variety of stakeholders and on the basis of locally pertinent information, needs, and priorities have a greater likelihood of success, reducing risks and vulnerability and being sustainable. This also builds on the notion that communities should inform the consideration and choice of adaptation options;
>
> The empowerment of communities, including by educating community representatives to serve as local researchers and by creating indigenous traditional knowledge frameworks" (FCCC 2014).

According to Kronk Warner (2015b), it is detrimental for the federal government to exclude tribes in climate-change initiatives because long histories of adaptation in response to colonialism, genocide, forced relocation, and climatic events have provided tribes with extensive experience with resistance, resilience, and adaptation. As sovereign entities, tribes have the ability to enact their own tribal laws and environmental regulations pertaining to land jurisdictions and tribal members. Tribes across the country are already using tribal law to transcend federal environmental law to enact innovative climate-change adaptation. These innovative tribal "laboratories" for examining environmental regulation provide examples and offer valuable approaches for adaptation and environmental regulation (Kronk Warner 2015b).

Despite these opportunities, there are challenges in the successful inclusion of indigenous perspectives and knowledges in climate-change policy and planning. These challenges include the cultural specificity of traditional knowledges; the ability and willingness for non-tribal partners to engage respectfully with traditional knowledges and practices; the long time frame necessary to build collaborative environments; minimal access to resources to address climate change; changes to

indigenous communities through the adoption of modern lifestyles; and risks to indigenous communities such as misappropriation, theft or misuse of their knowledges. In the United States, the National Congress of American Indians recognized these challenges for the incorporation of tribal traditional ecological knowledge with climate-change policies, research, and management (Resolution PDX-11-06) (NCAI 2011).

Protection of traditional knowledges—
Many academic and legal structures do not capture the complexities of indigenous community-based research and lack the mechanisms to hold researchers accountable to indigenous communities (Brewer and Kronk Warner 2015). The differences between Western and indigenous world views result in academic and legal research protocols, designed based on Western conceptions, unable to capture or protect the multifarious complexities of traditional knowledges (Brewer and Kronk Warner 2015). Most of the existing academic and legal structures for the protection of human subjects—institutional review boards (IRBs)—focus on questions of individual ethics and individual protection rather than community protection or protection of shared community knowledges (e.g., individual versus collective community knowledges). Even with the best of intentions, researchers must be held responsible for how their research, and the traditional knowledges being shared, might be used in the future. For example, traditional knowledge uncovered by a well-meaning plant biologist may be exploited by a pharmaceutical company in the creation of a "new" drug (Whitt 2009). For these reasons, indigenous communities are rightfully concerned about the use of indigenous knowledges in the creation of commercial products or the misuse of indigenous names, stories, symbols, and images (Paterson and Karjala 2003).

> The disturbance of an embedded landscape in which indigenous knowledge is so intimately tied to nature that it cannot be removed without either detracting from its original environment or rendering the knowledge less useful.

Intellectual property law—
Grounded in a Western perspective, the existing intellectual property system is unable to adequately protect traditional knowledges from exploitation (Brewer and Kronk Warner 2015, Kronk Warner 2015a, Oguamanam 2004, Whitt 2009). The intellectual property system protects property that emerges from intellectual and mental labor based on patent law (tangible things), trademark law (name or symbol), and copyright law (written and artistic). The intellectual property system is based on Western conceptions of individualized ownership, inventiveness, and commodification. Unlike intellectual property, traditional knowledges are generational and

not the product of a single inventor, new or novel, or "owned" by a limited number of people (Brewer and Kronk Warner 2015). As described by Whitt (2009: 167):

> Intellectual property law is at odds with vital features of many indigenous knowledge systems – by imposing individualized concepts of originality, inventiveness, rights, and informed consent; by eroding the shared nature of much indigenous knowledge; and by converting both knowledge and life forms into commodities to be harvest, altered, packaged, and sold for personal profit.

Oguamanam (2004:168–169) shared this sentiment and asserted that the price of using Western intellectual property law to protect traditional knowledges is "forced epistemological assimilation."

The World Intellectual Property Organization (WIPO) Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge, and Folklore is engaged in discussions on the protection of traditional knowledges (Schuler 2013). The WIPO committee may at some point provide explicit protection to traditional knowledges under international intellectual property law; WIPO has not reached a consensus (WIPO 2014). However, because the United States had a strong role in the construction of international property rights, there is a further risk that any explicit protections provided by WIPO would function to contain traditional knowledges within a Western legal paradigm, causing additional complications and harm to indigenous communities (Brewer and Kronk Warner 2015).

Tribal law—

Researchers must be accountable to indigenous communities in how they engage with traditional knowledges, the products of research, and how traditional knowledges are shared (or not shared) based on the free, prior, and informed consent of traditional knowledge holders and tribal governments (Brewer and Kronk Warner 2015, CTKW 2014). It is essential that research involving traditional knowledges occur with the free, prior, and informed consent of traditional knowledge holders and tribal governments, and that these individual knowledge holders and their tribal communities have the right to say "no" to participating in research (CTKW 2014). As tribes and nontribal partners engage in research partnerships, tribes should consider developing tribal Institutional Review Board (IRB) Protocol, such as the Institutional Review Board Manual for the Northwest Indian College (NWIC 2013). Unlike university IRBs that place the emphasis on individual protections, tribal IRBs can consider and address the impact of research on tribal communities, including "respect for communities, potential harms and benefits to communities, and justice in and for communities" (NWIC 2013: 2).

Research involving traditional knowledges should incorporate the free, prior, and informed consent of knowledge holders and tribal communities.

Owing to the inability of American and international property law to protect traditional knowledges, Brewer and Kronk Warner (2015) suggested that tribes pursue their own protections though tribal law, or "laws enacted by virtue on tribes' inherent sovereignty authority." They offer examples from laws enacted by the Colorado River Indian Tribes, Ho-Chunk Nation, and Sisseton-Wahpeton Oyate of the Lake Traverse Reservation that protect traditional knowledges. In each of these cases, tribal laws require researchers to obtain permits before conducting research and allow tribal control of the dissemination of research. In one example, the Colorado River Indian Tribes adopted a Human and Cultural Resource Code that created an ethical review board (ERB) a "specific and formal authorization body to provide protection of the Colorado River Indian Tribes' property including physical, real, cultural and intellectual property and communal property" (Colorado River Indian Tribes 2009: 1). This tribal law acknowledges communal property, provides mechanisms that maintain tribal control over traditional knowledges, and includes provisions that give jurisdiction over non-Indian researchers if traditional knowledge is exploited (Brewer and Kronk Warner 2015).

When creating a research agenda, researchers wishing to engage with traditional knowledges must be aware of the protocols of the community and tribal government in designing research protocols, and must consider how to ensure that research accomplishes the goals of the community (Brewer and Kronk Warner 2015). As information is gathered, it is important to understand the influence and uses that research may have outside of indigenous communities. The Wildlife Management Advisory Council North Slope offers a reference guide, Conduct of Traditional Knowledge Research, that "provides detailed technical guidance and, importantly, supporting rationale for best practices that should be fully considered by anyone contemplating, undertaking and applying traditional knowledge research on the Yukon North Slope" (Armitage and Kilburn 2015: vii).

Despite challenges associated with knowledge sharing, there have been recent successful accounts. For example, Hummel and Lake (2015) developed a blended approach that combines traditional knowledges with the scientific method to identify good, marginal, and poor conditions for the harvesting of beargrass (*Xerophyllum tenax*), a plant used in basket weaving. They assert that their blended approach advances the scientific method through the combination of qualitative and quantitative methods and allows traditional knowledge to be incorporated with scientific knowledge. They stress that, in the future, the best information on sustaining culturally important plants will come from research that accounts for both scientific and traditional knowledges. In another example, a cooperative effort between the Great

Lakes Indian Fish and Wildlife Commission and Forest Service's Forest Inventory and Analysis program worked with Anishinaabe gatherers to develop an inventory field guide for paper birch, a culturally important resource (Emery et al. 2014).

Community Health

American Indian and Alaska Native communities experience ongoing environmental health issues, including the legacies of pollutants and contamination, inadequate access to clean water, and reductions in the quality and quantity of culturally important species (Burger 2008, Burger et al. 2008). Changes in access to subsistence foods are associated with reliance on modern diets and increasing rates of modern diseases such as type 2 diabetes and obesity (Fleischhacker et al. 2012, McOliver et al. 2015). Continuing changes in climate and ecosystems will likely exacerbate existing environmental health issues (Brubaker et al. 2013, Donatuto 2011, Doyle et al. 2013, Ford 2014, Luber et al. 2014, McOliver et al. 2015).

Indigenous definitions of health and well-being reflect the interrelatedness of the social, cultural, spiritual, environmental, and psychological (Arquette et al. 2002, Donatuto et al. 2014) and offer a perspective on how climate change may affect community health and livelihoods. Impact assessments that examine health only from a Western perspective fail to adequately gauge the impact of climate change on American Indian tribes and Alaska Natives. Importantly, human health risk assessments that rely on individual and psychological health indicators are unable to capture the connection between community health and traditional foods (Donatuto et al 2011). This leaves indigenous communities with no viable framework to help communities adapt to climate-change impacts (Donatuto et al. 2011). Recent publications have described health frameworks based on indigenous perspectives (Brown et al. 2011, Donatuto et al. 2014, McOliver et al. 2015). For example, the Alaska Native Tribal Health Consortium formed a "One Health Group" based on a concept that recognizes that the health of humans is connected to the health of animals and the environment. Such efforts provide more culturally appropriate and accurate understandings of climate-change impacts to indigenous health (Donatuto et al. 2014, McOliver et al. 2015).

Box 1 describes six indigenous community health indicators (IHIs) used as a template by resource-based Coast Salish indigenous communities from coastal Washington state and British Columbia, Canada. The IHIs are meant to be a template of aspects of health that the community then refines and tailors to their specific priorities and context to identify adaptation priorities as presented by Donatuto et al. (N.d.).

Box 1

Community connection—

- **Work (job quality)**—community members have a job or role that they and other community members respect and they work together (mutual appreciation, respect, cooperation).
- **Sharing**—Sharing networks integral to healthy community, ensuring that everyone in the community receives traditional foods and other natural resources such as plant medicines, especially Elders.
- **Relations**—community members support, trust, and depend on each other.

Natural resource security—

- **Quality**—natural resources, including the elements (e.g., water) are abundant and healthy.
- **Access**—all resource use areas (i.e., Usual and Accustomed areas in Washington) are open to harvest or use (not closed or privatized).
- **Safety**—the natural resources themselves are healthy, not affected by pollution, climate change, etc.

Cultural use—

- **Sense of place**—engaging in traditional resource-based activities; continued reminder/connection to ancestors and homeland.
- **Respect/stewardship**—conferring respect of or to the natural resources and connections between humans, environment and spirit world; ensuring cultural resources are properly maintained.
- **Practice**—community assemblies able to follow appropriate customs (e.g., can obtain specific natural resources if needed such as cedar, certain foods, etc.); able to honor proper rituals, prayers and thoughtful intentions; able to satisfy spiritual/cultural needs, e.g., consume foods and medicines in order to satisfy Spirit's "hunger."

• *continued on next page*

Box 1 (continued)

Education—

- **The teachings**—knowledge, values and beliefs important to the community are maintained.
- **Elders**—the knowledge keepers who pass on the knowledge are valued and respected.
- **Youth**—the future; they receive and respect the knowledge.

Self-determination—

- **Healing/restoration**—availability of and access to healing opportunities (e.g., traditional medicines, language programs) for community members as well as ability to define and enact their own, chosen environmental or habitat restoration programs.
- **Development**—the ability for a community to determine and enact their own, chosen community enrichment activities in their homelands without detriment from externally imposed loss of resources.
- **Trust**—the community trusts and supports its government.

Resilience—

- **Self-Esteem**—the beliefs and evaluations people hold about themselves are positive, providing an internal guiding mechanism to steer and nurture people through challenges, improving control over outcomes.
- **Identity**—community members strongly connect with who they are in positive ways.
- **Resilience**—culture isn't stagnant, it adapts (e.g., people hunt with guns and use motorboats today but that does not discount the significance of harvesting), but preserving the ability to move within homelands and voluntarily adapt to changes, temporal or permanent (the "Seven Generations thinking").

Potential uses for this framework include the use of IHI to inform climate-change adaptation planning and "decision-making for recovering natural biophysical processes that sustain…natural resources and enhance community resilience" (Donatuto et al. 2014: 356).

The historical and sociocultural realities of indigenous communities require ethical considerations when addressing community health intervention (Brown et al. 2011). Rivkin et al. (2013) highlighted the importance of community participation through their use of community-wide presentations and discussions of research findings, as well as the prioritization of community expertise in the interpretation of findings and intervention development. This importance of community participation is echoed by the U.S. Environmental Protection Agency (EPA) Science to Achieve Results program, which funds tribal community-based research that brings together community members and academic researchers to create culturally specific and effective interventions to address the health disparities experienced by American Indian and Alaska Native communities (McOliver et al. 2015). Findings from five case studies identify and describe four key conditions necessary to achieve this goal (McOliver et al. 2015):

Community-based research, community participation and culturally specific interventions are necessary to improve community health.

- **Cultural relevance:** American Indian and Alaska Native (AIAN) communities define their health priorities themselves, as each community is unique and even neighboring communities may have very different health concerns. AIAN communities drive the research design, implementation, and dissemination of results to ensure relevance to the community, and are meaningfully engaged throughout the process if they are partnering with academic or other institutions.
- **Mutual respect and trust:** AIAN communities and their collaborators and funders need to establish, develop, and nurture respect and trust.
- **Adequate and sustained resources:** Long-term, sustaining resources are necessary for AIAN communities to evaluate and enact long-term health interventions.
- **Sustainable partnerships:** For AIAN communities that chose to partner, sustained committed relationships with academic or other research partners must be established and maintained past the completion of one project.

Taken together, these frameworks demonstrate the importance of culturally specific tribal voices in the assessment of, and intervention in, tribal community health.

Current Climate Impacts Affecting Indigenous Communities in the United States

Public Health

Climate-related phenomena such as decreased air quality, extreme weather events, wildfire, infectious disease, and temperature and precipitation extremes can lead to public health risks. Vulnerability to these public health risks will be experienced differently by individuals and communities depending on factors that include race, socioeconomic status, age, and geographic location (see Burger et al. 2008 and Ford 2012). As discussed in "Community Health," American Indians and Alaska Native communities experience public health issues that will likely be exacerbated by continuing changes in climate and ecosystems (Burger 2008, Burger et al. 2008). Climate change is predicted to compound existing physical health issues experienced by indigenous communities.

According to the Indian Health Service (IHS 2015), American Indian and Alaska Native communities experience disproportionate rates of chronic liver disease and cirrhosis, type 2 diabetes, unintentional injuries, respiratory diseases, cancers, liver disease, cardiovascular diseases, and suicides. These health impacts result from experiences of colonialism, racism, and trauma that have contributed to poor social and economic conditions, inadequate education, poverty, and discrimination in health services, cultural barriers, and isolation (Egeland and Harrison 2013, IHS 2015, Nelson 2013). As asserted by Egeland and Harrison (2013: 11):

> For indigenous peoples, determinants of health take on the additional dimensions of assaults on "indigeneity," including colonization and disassociation from their land, cultural and linguistic heritage and even families—when there has been forced residential schooling. In these situations, self-esteem and individual and group identity and self-determination have been eroded. The end result of these collective assaults on "indigeneity" are profound and far-reaching, and contribute to the wide gaps in indigenous health and well-being.

The legacies of assaults on indigenous peoples, including colonization, cultural suppression, and forced assimilation, have intergenerational consequences on physical and mental health and have been recognized as a source of suffering for indigenous communities (Gone 2013). However, public health issues are also associated with ongoing structural violence. Kirmayer et al. (2014: 311) argued that the focus on historical and cultural trauma may limit how the distress and redress are framed:

> By obscuring the ongoing forms of material dispossession and political domination, the discourse linking Indigenous culture and historical trauma

> may deflect attention from the fundamental structural causes of distress. Healing then is framed in terms of therapy for psychic wounds … rather than in terms of how people might find meaningful livelihoods within increasingly difficult constraints and imagine a viable future rooted in the material realities necessary for reproducing thriving communities at the local level.

To understand the existing health disparities experienced by indigenous communities, as well as the ways that these disparities will be exacerbated by climate change, one must consider not only historical trauma, but also structural violence rooted in poverty, inequality, and discrimination. In this section, we explore the impacts of climate change on six aspects of public health:

- Traditional food and medicine.
- Infectious disease.
- Contamination.
- Heat-related illnesses.
- Extreme weather.
- Air quality.

Traditional food and medicine—
The importance of traditional foods for indigenous health surpasses nutritional value. Traditional food systems are an important aspect of subsistence and medicinal practices and are closely related to community health and cultural traditions (Donatuto et al. 2011, 2014; Egeland and Harrison 2013; Lynn et al 2013; Turner and Clifton 2009). Relationships between indigenous peoples and traditional food systems were disrupted by colonialism and associated experiences of forced removal, relocation, and assimilation. During the past several decades, indigenous communities have experienced a "nutrition transition," characterized by the shift from traditional food practices and locally grown and hunted food to store-bought commodities of inferior nutritional value (Compher 2006). Despite these challenges, traditional foods remain an important part of indigenous physical and community health. As climate change affects the availability of and access to traditional food and the practices of gathering traditional foods (discussed below in "Food Security and Traditional Food"), the current health issues associated with the loss of traditional foods will likely be exacerbated (Donatuto et al. 2014).

Loss of traditional practices—
Some tribal people are unable to participate in traditional food practices because of the loss of land, language, and tradition. For others, climate-related impacts are increasing the costs associated with subsistence activities, requiring more expensive equipment and larger amounts of fuel, making traditional practices prohibitively

costly. As practices are lost, communities that maintain traditional subsistence practices become increasingly reliant on store-bought foods. For example, in rural Alaska, Native communities rely on a mix of both traditional and store-bought foods (Johnson et al. 2009). Although some studies show that older generations consume more traditional foods than younger generations, traditional foods supply important nutrients for all ages. Although store-bought foods supply most of the calories for the modern Alaska Native diet, traditional foods supply a high proportion of protein, iron, omega-3 fatty acids, and other nutrients (Johnson et al. 2009).

Nutrition transition and access to health foods—
Nutrition transition is associated with increases in modern diseases like obesity, diabetes, heart disease, and high blood pressure (Arquette et al. 2002, Brown et al. 2011, Fleischhacker et al. 2012). For many tribal communities, healthy foods are difficult to access. Reservations have been characterized as "food deserts," with little access to fresh fruits and vegetables (Schell and Gallo 2012). The lack of healthy store-bought foods means that nutrient-rich traditional foods are often replaced with less healthy alternatives (Kolahdooz et al. 2014). The food environment on the Apache reservation in Arizona consists of many gas station stores and few supermarkets, a moderate availability of fresh produce, and the reliance on off-reservation supermarkets for bulk shopping (Gittelsohn and Sharma 2009). In a study of the number and type of food stores on reservations in Washington State, O'Connell et al. (2011) found that tribal members living on a reservation had limited access to foods represented in the U.S. Department of Agriculture (USDA) Food Security Assessment Toolkit. Of the 22 reservations, 15 had only convenience food stores and five reservations did not have any type of food store (O'Connell et al. 2011). The classification of so many tribal reservations as "food deserts" inherently implies a reliance on Western food systems and does not recognize the importance of traditional foods.

Climate change is already affecting the availability of traditional foods (Lynn et al. 2013). On the Crow Reservation in south-central Montana, climate-related impacts are affecting the phenology, or seasonal changes, of juneberries, chokecherries, elderberries, and buffalo berries, which are stable foods in traditional diets (Doyle et al. 2013). Trees and shrubs are not producing fruit because they are budding out earlier in the spring (making them vulnerable to subsequent cold snaps that kill the blossoms); the timing of plants that do produce fruit has changed; and some trees are coming out of dormancy during winter warm spells and dying when temperatures fall (Doyle et al. 2013). In Kivalina, Alaska, melting sea ice is making hunting seals and whales more difficult and dangerous. One community member expressed the impact of these environmental changes on traditional subsistence practices:

> It's going to be hard to feed our kids. We have to stretch it out…For the bearded seal hunt, we used to get 14–16 bearded seals; this year we only got four. It was a very short year (Driscoll et al. 2013).

The negative impact of climate change on subsistence practices is contributing to an increased reliance on store-bought foods (Harper et al. 2015). However, as demonstrated by the following example from Nunatsiavut, Labrador, Canada, the increased intensity and duration of storms can disrupt the delivery of food to retail shops in remote communities.

> The conditions were horrible. People didn't get what they normally get for caribou and then you rely on store-food junk, because what other option do you have when you live in a remote fly-in-only community? And, the foods sources that you usually get to, you can't reach. There is not enough snow, there is not enough ice. It's alarming that we are just seeing the beginning of climate change… And if the weather is down [bad] for five weeks, how do you get in and out of your community to access services? How do you get food in there? I mean the stores had to actually, I mean their stock was down to bare bones because there was no way to get food in" (Harper et al. 2015).

The impact of climate change on traditional subsistence practices and the retail food industry demonstrates the vulnerability of the food system.

Traditional medicine—
Climate change also limits the ability of indigenous communities to use traditional medicines to respond to illness (Redsteer et al. in press). Environmental changes may result in the necessity to travel greater distances to find plants and herbs for the treatment of illnesses (Redsteer et al. in press). In Louisiana, saltwater inundation (largely attributed to dredging canals for oil pipelines) has destroyed plants and herbs used for traditional medicines (Maldonado 2014b).

> The majority of our trees are dying or dead, our herbs for healing are becoming extinct to us and our fruit and vegetable growth is being affected… [The plants] used for healing are gone and that everything they did back in 1950 is now gone… In the past, we used herbs and traditional remedies to maintain our health. But now, the plants are no longer here and more people are sick and we are forced to go to outside doctors with increasing bills and fees" (CLTC 2012: 13–14).

Many traditional foods have medicinal properties.

Many indigenous communities did not distinguish between nutrition and medicine. The plants used for subsistence also contained compounds with medicinal properties. Nutrient-dense food may protect against micronutrient deficiencies like anemia (Egeland and Harrison 2013). Many traditional foods also contain bioactive phytochemicals with the potential to protect against and mitigate chronic and degenerative diseases like obesity, diabetes, and cardiovascular disease (Schauss 2010). According to Schauss (2010), the current health disparities experienced by tribal communities could be reversed if tribes were able to return to their ancestral food sources.

Disproportionate rates of chronic disease among tribes in the United States result in state and federal health programs targeted to tribes, many of which originate from outside tribal communities and are not based on tribal experiences or tribal culture. Some have argued that the most successful health promotion programs are those grounded in tribal values and culture (Fleischhacker et al. 2012, Schell and Gallo 2012). A recent finding by Beil (2015) further reinforces this, demonstrating that individuals with higher levels of traditional knowledge display lower occurrences of chronic diseases.

For coastal Louisiana tribes, erosion and saltwater intrusion are causing the loss of traditional foods and medicines. Tribes are engaged in a number of practices that focus on rebuilding their subsistence livelihoods. With support from the USDA Plant Material Center, tribal members are pursuing the use of raised beds to protect culturally important plants from saltwater intrusion. Tribal members are also working with researchers to identify what plants remain in the wild and what plants have been lost to help identify preservation priorities (Maldonado 2014b).

Infectious disease—
Environmental change may cause changes in the transmission of infectious disease, which is sensitive to small changes in weather, landscape, and the diversity of animal hosts (Altizer et al. 2013). These ecosystem changes could result in new disease trajectories (Luber et al. 2014). Although some of these outbreaks can be anticipated, there are knowledge gaps about how climate change will influence specific infectious diseases in certain regions. These knowledge gaps make it difficult to prepare for potential public health impacts (Parkinson et al. 2015).

The impacts of climate change on disease distribution differ by region (Luber et al. 2014). The geographic zone of malaria is predicted to expand north, affecting portions of the Great Plains (Ojima et al. 2013). In the eastern woodlands, warmer summertime temperatures could lead to increased incidence of tropical diseases throughout the South and the accelerated spread of existing diseases like Lyme disease (Maynard 1998). New foodborne, waterborne, and insect-vector-borne diseases are already creating public health concerns for Alaska Natives (Nelson 2013, Virginia and Yalowitz 2011), and in the Pacific Islands, climate variations may lead to increased incidents of diseases like dengue fever (Keener et al. 2012).

Changing climates will change the geographic distribution of plants, animals, and insects, likely affecting distributions of infectious disease. Vector-borne diseases, or diseases transmitted by insects and ticks, will be affected by warming temperatures and the lengthening of the freeze-free season, or the amount of time between spring and autumn frosts (Brown et al. 2013, Luber et al. 2014). Vector ranges will change over time, and previously unexposed populations may become exposed. For example, in the Pacific Islands, climate variations may expand avian malaria to higher elevations (Keener et al. 2012). Although most pathogens are species-specific, some zoonotic diseases can be transmitted from animals to humans. In Alaska, as warmer temperatures allow infected animal hosts to survive the winter and increase their range and population, there is an increasing opportunity for these diseases to be transferred to humans (Hueffer et al. 2013, Parkinson et al. 2015). Tribal populations may be particularly vulnerable to zoonotic diseases because of traditional subsistence practices that place them in close contact with animals and food products. However, there are shortcomings in the knowledge of zoonotic diseases, including baseline levels of infection, lack of systematic surveillance, and inconsistent disease awareness, that must be addressed to ensure preparation for potential public health impacts (Hueffer et al. 2013).

Extreme weather events are associated with communicable diseases such as pneumonia, skin infections, malaria, dengue fever, and diarrheal disease because of the damage and disruption of water and sanitation infrastructure (Brubaker et al. 2011b, Downing and Cuerrier 2011, Ford et al. 2010). For example, in 2004, the village of Kivalina experienced a storm surge that damaged the sewage drain field of the washeteria, the community's only public toilet, laundry, and shower facility. This damage resulted in limited washeteria operation for the next few years, including closure for 5 consecutive months in 2005. According to the Alaska Native Tribal Health Consortium, the closure of the washeteria corresponds with increased rates of skin infections (Brubaker et al. 2009).

Many Alaska Natives practice subsistence hunting and fishing and rely on stable temperatures for traditional food preservation and storage. Traditional foods practices include aboveground air-drying, smoking, and fermentation, and belowground cold storage. Warming temperatures and melting permafrost may disrupt the preservation and preparation of traditional foods, increasing chances of botulism and food-borne disease outbreaks (McLaughlin et al. 2004, Parkinson et al. 2015). Melting permafrost may also cause food stored belowground in traditional food cellars to spoil (Brubaker et al. 2009, 2011b).

Contamination—
Climate change is associated with the contamination of traditional foods and water sources (Burger et al. 2008; see Rose et al. 2001). Exposure to waterborne and food-borne pathogens can occur through contaminated drinking water, seafood, or fresh produce. Climate affects the survival, growth, transport, and dissemination of pathogens through rainfall, runoff, and temperature. Increasing water temperatures can lead to shellfish and finfish disease and contamination (Cozzetto et al. 2013a, 2013b). American Indian and Alaska Native populations whose traditional diets rely on seafood, the Swinomish for example, are at greater risk of toxic seafood consumption (SITC 2010). The Mohawk Council of Akwesasne discovered that culturally important fish populations were contaminated with mercury and PCBs from past manufacturing (Whyte in press). In Alaska, food contamination is occurring as the ice cellars used for food storage thaw (Brubaker et al. 2011b), and contamination and pollution associated with flooding and energy development has led many to question the safety of water and soil in Louisiana (Maldonado et al. 2014a).

Contaminated water is a vector for disease (Downing and Currier 2011). Drinking water can be contaminated by damage to water treatment facilities caused by permafrost melting or flooding that causes the overflow of drinking water or sewage treatment reservoirs. Contaminated water supplies are associated with communicable diseases such as diarrheal disease (Downing and Cuerrier 2011).

Many tribes express concern about the quality of water resources. For example, in the Bering Strait region, increasing water temperatures have resulted in algal blooms that lead many to question water quality (Brubaker et al. 2015, Rosen and Amand 2015). The frequency and range of algal blooms is likely to increase, threatening shellfish populations and human health (Luber et al. 2014). These concerns are well grounded, as other literature confirms contamination of water resources by thawing permafrost, parasites and diseases, and bacterial contamination (Cozzetto et al. 2013a, Doyle et al. 2013, Luber et al. 2014, NCA 2014, Rose 2001).

Contamination of traditional foods and medicines can also occur as a result of the extractive practices of the fossil fuel industry. In coastal Louisiana, tribes

experience high rates of diabetes, cancer, and high blood pressure as a result of "health-threatening social conditions" originating from industrial contamination, toxic industries, chemicals from dispersants, and oil spills (Maldonado 2014a; Maldonado et al. 2013). Community members at a Louisiana workshop in 2012 described firsthand experience with such negative health outcomes:

> Before, longevity was a part of our heritage, but now we are the sacrificed communities and our people are dying younger because of new diseases we never had before (CLTC 2012: 15).

In Kiana, Alaska, rising temperatures are increasing the likelihood of food-borne pathogens. In response, residents are taking precautions in the preparation and storage of traditional foods to prevent food-borne illnesses. These precautions include wearing gloves while harvesting game, thoroughly cooking meat, thoroughly cleaning surfaces, and monitoring disease levels in subsistence resources (Brubaker and Chavan 2011).

Heat-related illnesses—
In the United States, heat stress is the leading cause of weather-related mortality (Brown et al. 2013). Based on projections made in the National Climate Assessment (2014), temperatures may rise 2 to 4 °F over the next few decades in most areas of the United States. This may increase the frequency, severity, and duration of extreme heat events and the experiences of heat exhaustion and stroke. Those most at risk of heat-related illnesses include children, elders, ailing, and the homeless (Luber et al. 2014, SITC 2010).

The Swinomish Tribe's Climate Adaptation Action Plan (2010) characterizes heat-related illness as a "medium-high" risk for tribal members. Tribal elders of the Crow reservation in south-central Montana are already raising concern about the impact of increasing summer temperatures on tribal populations during outdoor ceremonies (Doyle et al. 2013). In the Great Plains, lack of adequate housing leaves many without protection from extreme temperatures (Ojima et al. 2012). At the Oklahoma Inter-Tribal Meeting (Riley et al. 2011), extreme heat was cited as a health danger for tribal members without air-conditioning, and one participant described how extreme heat had caused the death of three tribal elders (Riley et al. 2012).

The Swinomish Adaptation Action Plan addresses the increased risk of heat-related illnesses on tribal communities by increasing community education, emergency preparation, and the development of a heat alert warning system. Additional strategies include retrofitting housing and structures with passive cooling systems that minimize the need for electric air conditioners. These designs include features of traditional longhouses and native trees, shrubs, and deciduous trees on western and southern exposures of homes (SITC 2010).

Extreme weather—

Extreme weather events are becoming more frequent, and more severe, and may result in permanent community displacement.

Increases in extreme weather events are associated with direct and indirect mortality and morbidity in indigenous populations (see Ebi 2011 for the U.S. public). In the Arctic, extreme weather events like storms and floods, and their increasing unpredictability, pose direct and indirect threats to the health of Alaska Natives (Willox et al. 2015).

Although extreme weather events have been a historical feature of many biophysical environments, their frequency and severity has been exacerbated by climate change (Downing and Cuerrier 2011). Increases in precipitation extremes and heavy rainfall have led to increasing incidents of severe flooding (Luber et al. 2014). Flooding is associated with direct and indirect impacts on human mortality and morbidity. In the United States, flooding is the second deadliest weather-related hazard (Luber et al. 2014). In a study spanning more than three decades, Dittmann (1994) reported an average of 119 flood deaths per year. Following extreme precipitation, waterborne disease outbreaks, and mold contamination from water intrusion that causes respiratory problems like asthma, phenomena, and respiratory syncytial virus (RSV) are increasing in frequency (Luber et al. 2014).

At the Oklahoma Inter-Tribal Meeting on Climate Variability and Change in 2011 (Riley et al. 2012), participants discussed the impact of heavy rain on tribes. Heavy rain and flooding may cause the contamination of waters, crops, livestock and cattle with heavy metals. Drought also presents a risk to human health by increasing exposure to wildfires, extreme heat, flash flooding, reduced water quality and quantity, and diminished air quality resulting from dust storms (Luber et al. 2014).

Extreme weather events and biophysical changes may lead to permanent community displacement, or **climigration** (Maldonado et al. 2013). For indigenous communities, extreme weather events compound effects from other political, economic, and

social factors to create a multicausal forced displacement (Maldonado 2014a, 2014b). For example, in Newtok, a Yup'ik Eskimo Village in western Alaska, six extreme weather events between 1989 and 2006 (five of which were classified by the Federal Emergency Management Agency [FEMA] as disasters) had devastating consequences on community infrastructure like homes, food storage, roads, and utilities. The high cost of building and road repairs overwhelmed the community's limited financial resources. These damages are now forcing community relocation (Chief et al. 2014, Maldonado et al. 2013, Willox et al. 2015). According to testimony to the U.S. Senate Committee on Appropriations by Robert A. Robinson, managing director of the Government Accounting Office's Natural Resources and Environment Team, flooding and erosion caused by warming temperatures threaten 86 percent of Alaska Native villages, and 31 Alaska Native villages qualify for permanent relocation (GAO 2004). Similarly, hurricanes off the Louisiana coast have caused a dramatic decrease in the population of the indigenous community on the Isle de Jean Charles, from about 325 people and 78 houses in 2002 to a current 70 people and 25 houses, as people have been forced to relocate by the loss of their homes to flooding (Maldonado 2014a).

Air quality—
Air quality can be affected by the concentration of allergens, particulate matter, and ground-level ozone. Warmer temperatures and more frost-free days will likely lead to a longer growing season and increased pollen production (Brown et al. 2013, Luber et al. 2014). As plant habitats change, so will the distribution of pollen-generating species and some may disappear and be replaced with new allergens. Variations in climate could affect the intercontinental transport of dust, pollen, and mold (Brown et al. 2013), and possibly increase the content and potency of allergens (Brown et al. 2013, Ferguson et al. 2011). All these changes have the potential to worsen allergen sensitization and asthma (Luber et al. 2014).

Increased precipitation and flooding can cause indoor air quality problems (e.g., fungus and mold) that may contribute further to allergies and asthma. Many indigenous communities currently struggle with air quality problems associated with mold. In 2011 and 2013, mold and resulting respiratory concerns led to the closing of the Navajo Nation's administrative offices in Window Rock (Cozzetto et al. 2013a). Similarly, in 2011, many residents of the Crow Reservation in south-central Montana experienced household mold infestations following a flood of the Little Big Horn River (Doyle et al. 2013).

Wildfire suppression and drier conditions have led to longer wildfire seasons and an increase in wildfire frequency and extent (Brown et al. 2013). Wildfire smoke contains particulate matter, carbon monoxide, nitrogen oxides, and other ozone precursors that can negatively affect human health (Luber et al. 2014).

Exposure to landscape smoke can cause respiratory infections, asthma, bronchitis, chest pain, chronic obstructive pulmonary disease, other lung illnesses, and death (Luber et al. 2014). In Oklahoma, poor air quality prevents elders from going outside (Riley et al. 2012).

Mental Health

Climate change has been associated with increased rates of mood and anxiety disorders, strong emotional responses, and loss of connections to homeland and social networks (Willox et al. 2013). Indigenous communities are particularly vulnerable to mental health impacts because of the importance of place to many indigenous peoples (Willox et al. 2013). Many tribes experience historical grief associated with loss of homelands, and their traditional way of life, which may be worsened by climate change (Luber et al. 2014). Based on in-depth interviews with tribal members and health professionals in the Inuit community of Rigolet, Nunatsiavut, Labrador, Canada, Willox et al. (2015) described five connections between biophysical climate change and psychological health. These connections are described in more detail below.

1. Changes to sense of place and existing practices.
2. Physical health impacts that influence mental health.
3. Damage to the built environment and infrastructure.
4. Indirect impacts from narratives shared through media.
5. The magnification or compounding of existing stressors.

These connections between biophysical climate change and psychological health provide a comprehensive framework to organize the impacts of climate change on mental health. We use this framework below to examine how climate change currently affects, and is projected to affect, the mental health of indigenous communities.

Changes to sense of place and existing practices—
The strong connection with place makes indigenous peoples particularly vulnerable to distress from climate change. Changes to or loss of culturally important places, subsistence practices, and culturally important species can negatively impact mental health (Willox et al. 2013, 2015).

> [M]any indigenous populations in the Circumpolar North continue land-based lifestyles and experience an interdependent relationship with the land, where identity, self-confidence, and socio-cultural and socio-spiritual significance emerges, in part, from one's connection to the land and to place. The land, then, is a site for deep healing, renewal, and revival and is vital to concepts of well-being, enrichment of the mind, body, and spirit, and resilience and not being on the land can cause deep psychological stress (Willox et al. 2015).

American Indian and Alaska Native populations already are experiencing changes to culturally important places and species (Cozzetto et al. 2013a, Lynn et al. 2013, Voggesser et al. 2013). Willox et al. (2013a) found that individuals unable to continue land-based activities because of climate change or economic barriers feel "stuck" or "trapped" and experience frustration, anger, distress, anxiety, and depression.

Participants at a 1998 Alaska workshop designed to engage community members in the assessment of climate impacts and priorities for adaptation, described how the inability to fulfill traditional subsistence activities affected mental health and caused feelings of isolation:

> Many elderly who can no longer participate in more rigorous hunting activities count on being able to pick berries or ice fish. Being stuck in camp and failing to accomplish these activities dramatically affects their quality of life and their personal sense of contributing to the community. In addition, common to all age groups is the spiritual need to feel that one is a productive and contributing individual (Callaway et al. 1999).

Kukarenko (2011) described how a number of studies link the disruption of traditional masculine roles with problems in identity and loss of self-esteem, and increased occurrences of psychosocial disorders like suicide and alcoholism. The impact of environmental change on the mental well-being of young men was expressed at workshop proceedings in Alaska. Participants vocalized concern that the interruption of subsistence activities, and thus their inability to contribute to the community, was negatively affecting the self-esteem of young men and exacerbating existing drug and alcohol use (Callaway et al. 1999).

For indigenous communities, the loss of connection to place and associated practices can threaten cultural identity and mental health. Sakakibara (2008) demonstrated how the Inupiat in Point Hope, Alaska, use contemporary storytelling as a critical form of cultural adaptation. Inupiat people at Point Hope are experiencing climate-induced changes to homeland, sense of place, and environmental kinship, that threaten culture and cultural identity. Storytelling reveals and fosters adaptation, allowing residents to maintain their connections to dramatically shifting places and cope with an uncertain future.

Physical health impacts that influence mental health—
The impacts of climate change on physical health can contribute to increasing mental health problems. Increases in disease, food insecurity, and rates of mortality and morbidity may affect mental health (Willox et al. 2015). For example, changing weather makes hunting more dangerous in the Arctic, thereby increasing the risk of death or injury. This increased risk can cause fear and anxiety in members of the community who may worry about their safety and the safety of others (Willox et al. 2015).

Climate change affects physical health and increases levels of fear and anxiety, and depression.

Damage to built environment and infrastructure—
Climate change can result in the destruction of community infrastructure, and, in some cases, displacement (Bronen 2013, Maldonado 2014a, Maldonado et al. 2013). These experiences may contribute to such mental health problems as anxiety and depression (Willox et al. 2015).

The magnification or compounding of existing stressors—
Using a historical trauma framework, Jacob (2013: 11) explained how legacies of colonialism can span across generations and intensify over time.

> Within this theoretical framework, the many social problems facing indigenous peoples are evidence of a traumatic response to colonial violence…If the traumatic response to colonialism goes unaddressed and unresolved, the healing of the soul would not happen. The trauma will worsen across generations. The soul wound is an important concept for decolonizing work because it accurately explains that the root cause of many social problems can be traced back to historical and ongoing forms of settler-colonial violence.

Historical traumas and the introduction of alcohol have resulted in high rates of substance abuse, suicide, and violence within indigenous communities (Weaver 2009).

Climate-related disasters also affect mental health. Disasters produce widespread physiological distress, physical health problems, social disruptions among general populations, and psychological disorders among some individuals. After a disaster, some individuals may be more susceptible to stress and maladaptive coping strategies (Jenkins and Phillips 2008).

Some data suggest that violence against women increases after disasters. For example, after Hurricane Katrina, gender-based violence in Mississippi increased from a daily rate of 4.6 per 100,000 to 16.3 per 100,000 (Enarson 2011). This increased vulnerability is associated with lower earnings and the presence of children. For indigenous women, climate-change resilience is complicated by

socioeconomic and environmental challenges created by the intersection of race and gender. Because American Indian and Alaska Native women already experience high rates of violence, they will likely experience increased vulnerability to escalating rates of gender-based violence post-disasters (Vinyeta et al. 2015). However, according to the U.S. Department of Justice, non-Native men perpetrate 67 percent of reported cases of rape or sexual assault against American Indian or Alaskan Native women (Bachman et al. 2008).

Indirect impacts from narratives shared through media—Individuals also experience climate change though indirect channels such as books, social media, regulations, and news sources that portray indigenous populations as the most vulnerable to climate change (Willox et al. 2015). Although many indigenous communities do experience disproportionate vulnerability to climate-change impacts, vulnerability results from colonial structures that limit traditional adaptation strategies. Vulnerability is often described as an inherent trait of indigenous communities rather than the result of complex social and ecological conditions (Marino 2015). Many of these narratives depict indigenous culture on the brink of extinction and indigenous people as lacking agency and resilience. This stigmatizes indigenous communities and can reinforce stereotypes about indigenous communities "needing the help of white outsiders" (Marino 2015: 29). According to Willox et al. (2015), these narratives paired with direct experiences of environmental change may intensify stress, anxiety, and fear. These indirect impacts shared through media can be intensified by the exclusion of indigenous voices from top-down adaptation policies that can further inhibit adaptive capacity. As described by Willox et al. (2015: 10):

> The injustice of having global climate concern and associated actions foisted disproportionately upon local communities—largely in the absence of local channels for political engagement that can effect decisions at a broader scale—may further undermine feelings of agency and contribute to stress.

Food Security and Traditional Foods

American Indians and Alaska Natives rely on a variety of local plant, animal, and fungi species for food, ceremonial, community, and economic activities (Bennett et al. 2014a, Lynn et al. 2013, Whyte in press). Some examples of traditional foods discussed in the literature include wild rice, shellfish, beans, moose, deer, berries, caribou, walrus, corn, squash, fish, and seal (Bennett et al. 2014a). These traditional foods play a vital role in tribal culture and well-being (Lynn et al. 2013, Whyte in press). This was demonstrated by Michelle (2012) who explored the

multifaceted relationship between berries and indigenous peoples in the Northeast to demonstrate the holistic aspects of wellness. For the Wabanaki people, berry plants are essential to their physical, emotional, psychological, and spiritual health (Michelle 2012). Whyte (in press) described the relationship between indigenous communities and traditional foods as "collective self-determination." According to Whyte (in press):

> Collective self-determination refers to a group's ability to provide the cultural, social, economic and political relations needed for its members to pursue good lives. Food contributes to collective self-determination through its integral roles in family and ceremonial life, as a source of nourishment and income, as a facilitator of trust and goodwill in society, as a carrier of a group's heritage and knowledge, and as a vital good that political leaders are entrusted to protect through laws and policies.

As climate change makes the continuation of subsistence practices increasingly difficult, climate impacts on traditional foods cannot be understood without examining the social, economic, and political stressors that influence how communities interact with their environments (Moerlein and Carothers 2012: 7).

> The increasing cost of participating in subsistence activities and dramatic changes in the social context of Arctic indigenous communities are causing a seeming decline in local fishing and hunting knowledge and level of participation in subsistence practices. Thus, these communities face a total environment of change, whereby environmental changes and broader socioeconomic challenges are jointly shifting and remaking human-environment relationships.

Some tribal communities are combating this "total environment of change" with adaptation initiatives that foster cultural identity by strengthening connection to place and documenting traditional knowledges and languages. For example, many Alaska Native villages hold culture camps, where elders share stories and knowledges that communicate traditional practices and cultural connections to place (Kofinas et al. 2010). Elders use stories and narratives to communicate values of humility, gratitude, self-reliance, attentiveness, responsibility, and responsiveness that are essential for subsistence living (Anthony 2013). These cultural initiatives aim to sustain cultural values and strengthen resilience within the changing socio-ecological context (Kofinas et al. 2010).

To maintain a relationship to traditional foods vital to cultural well-being, adaptation strategies must recognize the historical and current cultural importance of traditional foods as well as the links between access to traditional foods and current treaties, policies, and federal responsibilities (Lynn et al. 2013: 553):

> Tribes view climate change adaptation in light of their reciprocal relations to care for and respect the natural resources… . As a result of these relationships of reciprocity and responsibility between tribe and nature and existing policies, Indian tribes' vulnerability to climate change, and the adaptation strategies they adopt are multifaceted and deeply rooted in complex historical context.

Formal and informal institutions, policies, and regulation hinder many adaptation practices that could be mitigated with co-management practices (Kofinas et al. 2010). Federally recognized tribes have the authority to implement adaptation strategies and influence the climate-change policies of other governments. Tribal engagement in local, regional, and national adaptation planning related to traditional foods can help tribal and nontribal resource managers respond to the threats of climate change (Lynn et al. 2013).

Availability and access—
Climate variation destabilizes food security by affecting the availability of, and access to, traditional foods, their potential contamination, their storage, and peoples' confidence in their safety (Brubaker et al. 2015). In Alaska, thinning sea ice and a shorter ice season make travel to traditional subsistence hunting grounds more dangerous and costly (Brubaker et al. 2015). For example, Ford et al. (2013) used real-time observations, community-based monitoring, and mixed methods to explore how Inuit harvesters in Iqaluit, Nunavut, experience climate change. Researchers found that sea ice is rapidly changing, affecting trail conditions, safety, and access to harvesting areas. Although previous research suggested that Inuit communities are highly adaptive to climate change, Ford et al. (2013) argued that sociospatial reorganization has reduced the flexibility of harvesting activities, making climate change a more serious threat to the harvesting sector than previously assumed.

As climate change causes wide-scale ecosystem change, the homelands and ranges of culturally important species are beginning to shift, with some species becoming rare or absent from tribal territories and reserved lands (Lynn et al. 2013, Montag et al. 2014). For some tribes, climate change is affecting regional to local terrestrial and freshwater habitat quality; in response, tribally valued wildlife and fish subsistence and ceremonial use species are becoming more variable in their "predictable" timing and habitat occurrence based on former traditional knowledge. Changing demographics and abundance of valued wildlife and fish species decrease harvesting success rates, and increase travel and search times for hunters and fishers. For example, as drought affects forest-based food resources (e.g., berries, nuts, and seeds) both indigenous people and wildlife experience greater competition for, or a reduction in the amount of food resource that can be harvested

at a given location or time (Cordalis and Suagee 2008). Similarly, anadromous fish in the ocean (e.g., salmon) are entering river systems and migrating up watersheds in fewer numbers owing to reduced high-elevation snowpack and subsequent lower creek and river flows, coupled with warmer water temperatures (Bernton 2015, Houston 2015, Krakoff 2008, Northwest Indian Fisheries Commission 2015).

Traditional plants used for food and medicines are becoming increasingly difficult to locate and grow (CLTC 2012, Lynn et al. 2013, Maldonado et al. 2013, Voggesser et al. 2013). On the Navajo Reservation, the over-allocation of water and rising temperatures have caused periods of prolonged drought, making subsistence farming difficult (Redsteer et al. in press):

> People have quit farming because there is not enough rain; when corn is planted the wind starts blowing and the corn stops growing; people work for wages and don't depend on crops for food; younger generations don't know how to farm; the men who knew the songs for farming are gone; and the land is too crowded with people forced to relocate.

Similar drought impacts are affecting other southwest regional Pueblo farmers (Norton and Sandor 1997).

A 2008–2011 grant from the U.S. Environmental Protection Agency (EPA) Science to Achieve Results program facilitated a community-based participatory research program to assess the impacts of climate change on the traditional medicinal value and availability of indigenous berry resources in Alaska. The project brought together university researchers with physicians from the Alaska Native Tribal Health Consortium and Alaska Native community members from Akutan, Seldovia, and Point Hope, and integrated biological data relevant to wild berry bioactive properties with community perceptions of how climate change may affect berry habitat. This community-based participatory research was based on the priorities and needs of indigenous communities (McOliver et al. 2015).

Ocean acidification corrodes the calcium-carbonate shells of shellfish, disrupting their shell formation. Shellfish play a pivotal role in the marine food chain and their loss threatens the subsistence practices of communities that rely on marine protein (Lynn et al. 2013). There are also issues of new shellfish paralytic shellfish poisoning, a potentially fatal neuroparalytic condition, that occurs in southeast Alaska and the Aleutian Islands, where warmer water is resulting in more extensive outbreaks of toxic algae (Castrodale 2015).

Tribes in the Pacific Northwest are working to mitigate the impact of ocean acidification on culturally important salmon and other aquatic species. The Tulalip Tribe is attempting to mitigate negative impacts by restoring native marine vegetation such as seaweed, kelp, and eelgrass to coastal beaches. This marine vegetation provides shelter and foraging areas to marine species and creates microhabitats of lower pH that can give marine species a healthy start, preparing them for difficult struggles later in life. Additionally, restoring marine vegetation can help reduce shoreline erosion that threatens reservation lands. Preston Hardison (quoted in Wall 2013) stated that:

> The tribes are fixed by treaty, by their ancestors, and by their relationships to the land. They can't move. If species move away from tribal territories, they're lost to the tribe. This is why we have to act quickly to restore the health of the ecosystems, to keep as many species at home as possible in the face of this major event of climate change. We're also concerned about "tipping points" of thresholds. If the ecosystem is stressed beyond normal parameters, it can collapse.

Climate change, warmer water temperatures, ocean acidification, and environmental pollution are forcing dietary changes away from fish and shellfish.

Contamination—
Climate change and warmer water temperatures may facilitate the conversion of inorganic mercury to methylmercury (Booth and Zeller 2005). Methylmercury is a highly toxic substance that bioaccumulates and biomagnifies in organisms. This means that it accumulates more quickly than it is eliminated and increases in concentration as it travels up the food chain (Erwin and Munn 1997). Tribal members often consume larger amounts of fish and shellfish than the general population, increasing their exposure to methylmercury contamination (Cozzetto et al. 2013a, 2013b). Warmer water temperatures also increase people's susceptibility to consume marine life with diseases, poisons, and parasites (Cozzetto et al. 2013a).

Climate change may also exacerbate existing environmental pollution. For example, tribes in coastal Louisiana experience air, soil, and drinking water contamination resulting from associated industry, chemical dispersants, oil spills, and oil seepage. This contamination has forced dietary changes (CLTC 2012, Maldonado et al. 2013). This experience is described in Stories of Change, a Workshop Report incorporated in the National Climate Assessment (CLTC 2012: 14):

> Our seafood is gone. Pigs, hogs, cattle, deer, marsh hens, ducks, rabbits, and horses in our backyard are all gone. The gardens that once flourished behind our houses are no longer there. The trees where we wandered and got lost in are no longer there. The muskrats we trapped for food and income and spent hours upon hours skinning together in shared company are no longer there. The land is no longer there. Now it is open water.

For the Jamestown S'Klallam Tribe, algal blooms from the dinoflagellate Alexandrium Cantenella are increasing the likelihood of paralytic shellfish poisoning. Although Jamestown S'Klallam Tribe's rights to manage their ancestral shellfish beds are not currently recognized by the federal government or Washington state, they have pursued a variety of resilience strategies, including taking a leadership role in initiating public alert systems and establishing partnerships. Their tribal adaptation plan discusses strategies to reduce the risk of exposure to shellfish biotoxins by enhancing beach alert systems, monitoring programs, and coordination with county and state public health officers (Jamestown S'Klallam Tribe 2013).

Storage—
The preservation and storage of traditional foods is climate sensitive and vulnerable to climate variation (Brubaker et al. 2009, 2015). In Point Hope, Alaska, **sigl uaq**—traditional Inupiaq food storage cellars—are thawing and flooding, causing whale meat to spoil and increasing the risks of food-related illness (Brubaker et al. 2009). More frequent wet conditions are affecting the preservation of harvests in the Bering Strait region, often leaving only two good weeks of drying weather before rain (Brubaker et al. 2015).

Confidence—
Climate change and the fear of contamination are also affecting the confidence American Indian and Alaska Native communities have in their traditional foods (Cochran et al. 2013: 560). Participants at the Louisiana Workshop (2012) expressed frustration that they could no longer be certain what they were putting into their bodies. Residents of Stebbins, Alaska, expressed concern about food safety and sanitation after a sewage lagoon flooded onto important harvesting areas (Brubaker et al. 2015).

Impact to on and off reservation resources—
Climate change is altering the distribution of plant, animal, and aquatic species (Lynn et al. 2013, Voggesser et al. 2013). Treaty-protected hunting, gathering, and fishing rights are tied to reservations or usual and accustomed places. As species shift and populations change, their quantity, distribution, and timing may no longer be consistent with traditional tribal access. Although the literature discusses the potential for species shift and related impacts to treaty rights, it contains few references to cases or examples used to substantiate these impacts. As a central concern for tribal sovereignty, there is a need for formal efforts that measure and document changes in species distribution.

Water Resources

Climate-change impacts on water resources are discussed extensively in the literature. Projected impacts include decreased precipitation and increased drought in the South; increased precipitation, decrease in snowpack, and earlier snowmelt in the North; increased atmospheric potential for evapotranspiration; increased water temperatures in some rivers; decreased water quality owing to lower and more persistent low flows during drought and higher flows during floods; and increased demand for water (Georgakakos et al. 2014). Although these impacts will be experienced across the country, their impact on tribal communities may be more severe (Hanna 2007).

Water resources are important for tribal sustenance, economy, culture, and lifeways. For many indigenous communities, water has religious and cultural significance and is considered to be sacred (Cozzetto et al. 2013a, Krakoff 2008, TWWG 2012). Water is central to tribal economies, supporting agriculture, energy production, fisheries, forests, aquaculture, recreation, grazing, ceremony, and communities. Water is also central to tribal culture, providing habitat for native species that are important for food, medicines, and rituals (Royster 2012). Cozzetto et al. (2013a) identify five aspects of American Indian and Alaska Native water resources affected by climate change:

1. Tribal sovereignty and water rights.
2. Water supply and management.
3. Culturally important species.
4. Ranching and agriculture.
5. Soil quality.

We use the framework below to examine how climate change is currently challenging tribal water resources and is projected to continue doing so.

Tribal sovereignty and water rights—
Water rights are closely related to tribal vulnerability and adaptive capacity (Redsteer et al. 2013a). The legal basis for tribal water rights comes from the federal reserved rights doctrine that holds that tribal nations have reserved rights to lands and resources in treaties they signed with the federal government. In 1908, the Winters v. U.S. decision by the Supreme Court [207 US 564 (1908)] held that the treaties that created reservations implicitly reserved the water rights necessary to fulfill the current and future needs of the tribe and to fulfill the purposes of the reservations. This quantity includes water for agriculture, domestic livestock, recreation, cultural uses, and, in some cases, in-stream flows (Cozzetto et al. 2013a, Redsteer et al. 2013a) (see also Mondou 1998). The 1963 Supreme Court case Arizona v. California determined that water rights for reservations would be determined based on "practicably irrigable acres" (PIA). There are difficulties in how PIAs are quantified, including differences in the amount of tillable land from reservation to reservation, and quantifying water rights based on amount of tribal land rather than population (Goodman 2000, Redsteer et al. 2013a).

There are some barriers in federal law and policy that limit tribal adaptation and self-determination in relation to water resources (Royster 2012). States do not have the same legal responsibility to protect tribal water rights. Hanna (2007) discussed the McCarran Amendment, which gave state courts the right to determine and divide water rights, causing inconsistencies based on political sentiment, strength of legal representation, and state budget allocations. Other federal barriers include variability in (1) the measure used to quantify tribal water rights; (2) sources of water subject to water rights; (3) the use of tribal water rights, and restrictions to that use; (4) promulgated water codes and uses; and (5) water marketing (Royster 2012). Wilson (2014) explained that distinctions between Western and indigenous hydrosocial relations affect different approaches to water governance. Although both exist simultaneously within the same political space, the Western perspective is privileged, leaving the indigenous perspective unacknowledged and unprotected in water law and policy.

In 2010, only 10 percent of tribes had water rights recognized by the United States or were in the process of adjudicating them (TWWG 2012). As climate change continues to affect the availability and quality of water resources, tribal water rights become increasingly important. According to Cozzetto et al. (2013a: 7):

> Climate change impacts on water quantity, quality, and timing add to legal and planning complexities and compound concern that Indian water rights may be sacrificed under climate change resulting in unmet present and future human and environmental water demands.

Tribes are asserting their inherent water rights and sovereignty using strategies such as litigation to gain legal recognition of tribal water rights, as well as alternative strategies that do not rely on federal adjudication. Wilson (2014) described how grassroots and intertribal organizations, such as the Yukon River Inter-Tribal Watershed Council (YRITWC), allow indigenous peoples to assert water governance beyond their own territories.

> The work of the YRITWC and other similar organizations can contribute to the assertion of sovereignty by individual Alaska Native tribes and First Nations and facilitate the formulation of collective responses at the watershed scale to mitigate or adapt to alterations in water quality, quantity and rate of flow. Furthermore, the YRITWC's work with Alaska Native Tribes and First Nations in the Yukon River Basin can be understood as an example of Indigenous water governance that seeks to assert Indigenous sovereignty and inherent water rights through strategies that are not necessarily dependent on legal recognition (Wilson 2014: 8).

Water supply and management—
According to the Tribal Water Working Group (TWWG 2012), one of the most serious threats of climate change is the complication of water resource management. Tribal access to and management of water resources are based on water availability, geography, governance, treaty rights, recognition, and resources. Some tribes struggle with access to clean water, the power to address water quality issues, and the financial resources to regulate water issues, while others struggle with limited supply, pollution, and tribal authority (TWWG 2012). As a result of competing water uses and over-allocation of water resources in the Yakama River Basin, resource managers for the Confederated Tribes and Bands of the Yakama Nation are unable to meet current or future demand, or to prepare for potential climate impacts (Montag et al. 2014). This results in devastating consequences for first foods like salmon, directly affecting Yakama culture and tribal well-being (Montag et al. 2014).

One of the most serious threats of climate change is the complication of water resource management.

The problems associated with the management of water quality occur both on and off reservations. As a result of federal Indian policies like the Dawes Act of 1887, or the General Allotment Act, not all the land within reservation boundaries is owned by tribal members. The resulting mixed ownership creates conflict between tribal, state, county, and federal governing entities as they claim authority to regulate use and quality standards, or as they "challenge other's ability to do so" (TWWG 2012). Challenges to tribal authority and sovereignty can prevent the implementation of water quality standards or attempts at regulation. Although tribes are affected by off-reservation pollution and water use, their voices are often

marginalized in water resource management discussions (Cozzetto et al. 2013a). For example, in the Southwest, the Navajo Nation has senior water rights to the lower basin of the Colorado River, but has difficulty settling claims with surrounding neighboring states that rely on these waters for state users (Nania et al. 2014).

> The Yukon River Inter-Tribal Watershed Council, an intertribal organization consisting of 73 First Nations and Alaska Tribes, is responding to climate change threats in the Yukon River Basin through a practice of "traditional science" that combines traditional and scientific knowledges in a number of environmental programs and projects to respond to climate threats. These actions include the development and implementation of a Watershed Plan and development of water community-specific water strategies (Wilson 2014).

Culturally important species—
Culturally important aquatic species are essential for subsistence, cultural, and economic well-being of indigenous communities (Cozzetto et al. 2013a). Many of these species have already been negatively affected by land and resource management practices, habitat destruction, overfishing, hydroelectric dams, invasive species encroachment, and habitat degradation (Dittmer 2013). In the Pacific Northwest, culturally important salmon populations have been in decline for 150 years (Dittmer 2013). Climate impacts on fisheries are already intensifying population decline (Cozzetto 2013a, 2013b; Dittmer 2013; Grah and Beaulieu 2013). For example, the Swinomish Indian Tribal Community documented a 95-percent reduction of Chinook salmon in the Salish Sea since 1995 (SITC 2010). Another example of the cultural importance of salmon is offered by Montag et al. (2014), who described how salmon contribute to the five interconnected elements of Yakama tribal well-being, including first foods, family/individual well-being, tribal community well-being, ceremonies/celebrations/art, traditional-knowledge transmission, and the continuation of the Sahaptin language.

Rising average temperatures are increasing the temperatures of ocean and freshwater resources. Although some warmwater species will likely thrive in warmer conditions, coldwater fish, like trout and salmon that require cold water at various lifecycle stages, may decline (Jenni et al. 2014). The Fond du Lac Band of Lake Superior Chippewa (Minnesota) have experienced declines in trout and changes in fish populations, with new species taking over. In marine waters, changes in ocean temperature and acidity are also affecting culturally important fish and shellfish populations (Bennett et al. 2014a, Dalton et al. 2013), and Alaska is experiencing a northward shift in fish populations (Cochran et al. 2013).

The increasing frequency and severity of storms is causing flooding, habitat scouring, and the washing away of buried salmon eggs (Cozzetto et al. 2013a) and intertidal shellfish (Parker et al. 2006). The numbers of invasive species and non-game fish that can increase predation pressure will likely increase as temperature rises (Jenni et al. 2014).

In the Pacific Northwest and Alaska, three stages of the salmonids lifecycle occur in freshwater: spawning, incubation, and rearing. These freshwater stages depend on appropriate habitat (water depth and flow rate), food availability, and water temperature, all of which are or may be affected by climate change (Jenni et al. 2014). Declining fish health and populations threaten the requirement to conform to treaty rights and court decisions that dictate tribal share of harvestable fish populations. For example, the Boldt decision grants Columbia River tribes the right to 50 percent of harvestable fish runs (384 F. Supp 312 (1974). Fishing rights are threatened as warmer water temperatures, pollution, and development practices cause the supply and health of the salmon population to decline (Krakoff 2008, Montag et al. 2014).

In Nevada, the Pyramid Lake Paiute rely on two culturally important aquatic species, the Lahontan cutthroat and the cui-ui sucker fish (Gautam et al. 2013). The over-allocation of water resources to irrigation and energy caused lake levels to fall by 80 feet, and these populations to plummet. However, after passage of the 1973 Endangered Species Act, the tribe asserted water rights, created environmental management plans, and partnered with government agencies and university researchers. Since then, the cutthroat has been revived and the cui-ui, while still endangered, is recovering (Fisher 2014).

Ranching and agriculture—
Drought and changes in water availability are affecting ranching and agricultural practices. Climate change is projected to increase the frequency and duration of extreme weather events, like floods and drought (IPCC 2014, NCA 2014) with significant repercussions for ranching and agriculture (Hatfield et al. 2014). As temperatures increase, so will the necessity for agricultural irrigation, increasing production costs and the stress on water resources. In the Four Corners Region (southwestern Colorado, southeastern Utah, northeastern Arizona, and northwestern New Mexico), drought impacts have been worsened by increasing evapotranspiration rates, reduced soil moisture, and intensified stress on vegetation and local water sources (Ferguson et al. 2011, Redsteer et al. in press).

Many southwestern tribes depend on livestock as a significant part of their economy and have limited alternative livelihoods (Redsteer et al. 2013a, 2013b). For example, for the Navajo Nation, stock raising is an important aspect of traditional culture, and many families rely on livestock, specifically cattle, as a source of economic and food security (Redsteer et al. 2013b). Climate-related impacts to rangelands and livestock include drought, flooding, and dust storms. Drought and increased evaporation can leave ranchers without the water and crops necessary to feed livestock. For example, on the Navajo Reservation, the small stock ponds available for livestock often dry up during droughts and summer months (Nania et al. 2014), forcing residents to haul water for sheep and cattle (Ferguson et al. 2011). In Oklahoma, the 2010–2011 drought left farmers without the hay necessary to feed livestock, forcing many farmers to sell their livestock (Riley et al. 2012). For tribes in the Four Corners Region, drought has led to a rapid decline in both the carrying capacity of rangeland and range conditions, forcing ranchers to reduce the numbers of livestock (Ferguson et al. 2011). In the period 2001–2002, Navajo officials reported the death of 30,000 cattle (Redsteer et al. in press).

Soil quality—

Climate change is contributing to coastal and riverine erosion and drought-related land degradation (Cozzetto et al. 2013a). High tides and storms along Washington's Hoh River washed away some lands of the Hoh Indian Tribe, ultimately leading to their relocation (ITEP 2012). In Alaska, thawing permafrost, which contains carbon in the form of frozen organic matter, is raising concerns about changing ground cover and the release of carbon into the atmosphere (Schaefer et al. 2012).

In the Southwest, prolonged periods of drought are making sand dunes more active, leading to their widescale movement on the Navajo and Hopi Reservations. Dunes are susceptible to changes in temperature, precipitation, wind speed, and circulation patterns. Although vegetation can protect dunes from wind erosion, because of drought conditions there is not enough moisture to support plant life. Flooding can also contribute to the creation of new dune fields because of the sand provided by temporary drainages that flow during floods. It is likely that projected warmer and dryer conditions will mobilize sand dunes that are currently stabilized by vegetation. This process is difficult to reverse because vegetation would need to establish itself on a moving landform. There are very few plants that can survive sand burial or sand abrasion, and sand dunes are contributing to a loss of rare and endangered native plants and grazing lands (Redsteer et al. 2011a, 2011b, 2013a).

There is very little available in the literature regarding the indigenous knowledge of soil-based resources being affected by climate change. Traditional knowledge

about soils or geology, ethnopedology, can begin as a starting point (Barrera-Bassols et al. 2006). There are complex relationships among soils, vegetation and fungi, and the atmosphere that climate science is addressing, but little research has been conducted on tribal knowledge of these effects (Powlson 2005, Rustad et al. 2000).

The Navajo Climate Change Adaptation plan includes adaptation strategies for range resources and farming (Nania et al. 2014). As a sovereign nation, the Navajo Nation has the power to manage tribal rangelands and adopt and enforce their own adaptation efforts. Some of these adaptation strategies include improvements in range management, range restoration and reseeding, adjusting feed patterns for livestock, selecting breeds that adapt to warmer climates, improvements in water reliability, disease prevention and monitoring, and providing additional support for ranchers. Potential adaptation strategies for farming include water management and soil-erosion management techniques (Nania et al. 2014).

Terrestrial Ecosystems

Climate change exacerbates effects of invasive species, decreaseing the quality and quantity of forest resources and increasing forest mortality.

Forests are a central cultural and economic resource for many American Indians and Alaska Natives. There are 18 million ac of forest on federal trust lands, with 5.7 million ac designated for commercial forestry (NCAI 2015). Climate change is associated with increasing forest disturbances such as insect and pathogen outbreaks, invasive species, wildfire, and extreme events such as droughts, high winds, ice storms, hurricanes, and landslides induced by storms. Because of their close relationship to, and dependence on, forest ecosystems and landscapes, tribes are often the first to witness, understand, and experience the impacts of climate change on forests and woodlands (Parrotta and Agnoletti 2012).

Invasive species—
Climate change is likely to exacerbate the effects that invasive species have on forest resources (Dukes et al. 2009). Invasive species decrease the quality and quantity of forest resources and result in forest mortality. They directly affect subsistence and ceremonial practices by displacing native species (Voggesser et al. 2013). There is little literature that discusses how climate change will exacerbate invasive species and even less that explores how invasive species, coupled with climate change, will affect tribal forest resources. Although tribes and researchers are beginning to document the impacts of invasive species on forest ecosystems (Ranco et al. 2012, SITC 2010, Voggesser et al. 2013), this area requires future research.

Insects and pests—
In the Midwest and East, emerald ash borer (EAB) infestations are having devastating impacts on ash tree populations and indigenous cultural and economic traditions (Voggesser et al. 2013). The black ash is a "cultural keystone species" for the Wabanaki people of Maine and the Maritimes. Voggesser et al. (2013: 6–7) [relying on Garibaldi and Turner (2004)], explained:

> Something is deemed a cultural keystone species by: the intensity and multiplicity of use, naming and terminology in a language, role in narratives or ceremonies, persistence and memory of use, level of unique position in culture, and the extent to which it provides opportunities for resource acquisition beyond the territory.

The black ash has cultural, social, and economic importance. It is referenced in the Wabanaki origin stories and used in traditional basketweaving (Voggesser et al. 2013).

Longer growing seasons and warmer winters may increase the damage done by invasive pests and insects. In some cases, warming may allow pests and insects to survive year-round, increasing damage to forest health (Joyce et al. 2014). For example, the Swinomish Indian Reservation has experienced increased mountain pine beetle (MPB) outbreaks (SITC 2010) as rising temperatures now allow the MPB to live year-round and survive at higher elevations (ICTMN 2015). In 2013, the MPB was responsible for more than 35 percent of forest mortality nationwide (Jenkins 2015).

Pathogens and diseases—
Climate change may also affect forest heath by changing the trajectories of pathogen outbreaks. The pathogen that causes the tree disease "sudden oak death," *Phytophthora ramorum*, is sensitive to changes in humidity and temperature. In coastal California, temperature change and increasing fire frequency have led to increases in the tree disease. Many California tribes, including the Yurok, Paiute, Miwok, and Western Mono, rely on oaks and acorns as a source of traditional food stables, traditional medicines, and dyes (Anderson 2005, Redsteer et al. 2013a).
In the Pacific Northwest, the distribution of Swiss needle cast (SNC), a foliage disease specific to Douglas-fir, may move farther north and inland. Swiss needle cast reduces forest growth by 20 to 50 percent and threatens the forest resources of the Quinault Indian Nation, which is heavily dependent on forests and timber. The 208,000 ac of forest on the Quinault Indian Reservation is located within the SNC infection zone, with about 5 percent of the forest already infected (NFWPCA 2014). Invasive pathogens are expected to continue spreading, and may be worsened by climate change, affecting native forested ecosystems from which many tribes rely for subsistence and economic livelihoods (Voggesser et al. 2013).

In Maine, Wabanaki black ash harvesters and basketmakers are working with university researchers, federal foresters, and others to prevent, detect and respond to the emerald ash borer. These blended-knowledge approaches have resulted in seed collection, mapping ash resources, creating policy guidelines, and public education and stakeholder engagement (Ranco et al. 2012).

Wildfires—

Drought can compromise the health of forest ecosystems by making trees more vulnerable to pests, invasive species, and pathogens (Joyce et al. 2014). Trees that are drier because of death or illness are increasingly vulnerable to fire and burn at higher temperatures (Joyce et al. 2014). Higher severity and more extensive fires increase flood susceptibility and change properties of soil, permanently altering the landscape. Longer wildfire seasons and increased wildfire risks threaten tribal food and resources (e.g., the Swinomish Indian Tribal Community; the Fond du Lac Band of Lake Superior, Chippewa, Minnesota; and coastal Louisiana tribes). For example, a fire destroyed 94 percent of the La Jolla reservation, including oak forests (Redsteer et al. 2013a).

In addition to climate change, terrestrial ecosystems have been affected by interruption and prevention of traditional management practices. For many indigenous communities, fire and ceremony are used in the traditional management of fisheries and forests. For example, three-fourths of the Karuk Tribe's traditional food sources and culturally important species are enhanced by fire (Norgaard 2014). Throughout the 20th century, U.S. policy was aimed at minimizing wildfires through wildfire suppression and exclusion. This policy caused radical landscape changes, including changes in the availability of culturally important plants and animals. Norgaard (2014: 76) explored the social impacts of wildfire exclusion on the Karuk:

> From a Karuk perspective, the exclusion of fire from the landscape creates a situation of denied access to traditional foods and spiritual practices, puts cultural identity at risk and infringes upon political sovereignty. On a more individual level, the altered forest conditions create social strain for the individuals who hold the responsibilities to tend to specific places and to provide food to the community for subsistence as well as ceremonial purposes.

The ecological, economic, social, political, and psychological consequences of wildfire exclusion are interconnected and must be understood together. Norgaard (2014: 79) demonstrated this with the words of Karuk cultural biologist, dipnet fisherman, and spiritual leader Ron Reed:

> Without fire, the landscape changes dramatically. And in that process the traditional foods that we need for a sustainable lifestyle become unavailable after a certain point. So what that does to the tribal community, the reason we are going back to that landscape is no longer there. So the spiritual connection to the landscape is altered significantly. When there is no food, when there is no food for regalia species, that we depend upon for food and fiber, when they aren't around because there is no food for them, then there is no reason to go there. When we don't go back to places that we are used to, accustomed to, part of our lifestyle is curtailed dramatically. So you have health consequences. Your mental aspect of life is severed from the spiritual relationship with the earth, with the Great Creator. So we're not getting the nutrition that we need, we're not getting the exercise that we need, and we're not replenishing the spiritual balance that creates harmony and diversity throughout the landscape.

Chapin et al. (2008) explored the impacts of fire suppression, fire ignition, and climate change on fire regimes in interior Alaska, a region that has experienced a dramatic increase in the number, acreage burned and severity of wildfires since the 1960s. Their findings demonstrate that the greatest wildfire risk is associated with areas in which wildfire suppression has occurred. Chapin et al. (2008) argued that reintroduction of fire as a land management strategy is the best way to minimize the destruction from fires. In Alaska and other U.S. regions, tribal culture and dependency on fire-influenced forest conditions can differ (Huntington et al. 2005). As North American fire regimes change in response to climate, some tribes or indigenous communities may be affected or respond in different ways (Natcher et al. 2007, Norgaard 2014, Rasmussen et al. 2007).

As the benefits of traditional practices become increasingly valued in forest and resource management practices, tribes like the Confederated Salish and Kootenai Tribes are including the use of fire in their climate adaptation plans to minimize the risk of wildfires on tribal resources (CSKT 2013).

Tribal Economies

Climate change results in additional financial burdens for many tribes that are experiencing climate-related events such as severe weather, flooding, and sea-level rise (Bennett et al 2014a). According to Huntington et al. (2012), individuals and households experience the burden of economic consequence resulting from climate change.

> The balance of economic costs will be borne by individuals and households in the form, for example, of higher prices for food and water, higher prices for or non-availability of insurance, the purchase of defensive technologies like air conditioners, or in extreme cases, household migration decisions, and potentially, the abandonment of towns or regions (Huntington et al. 2012: 67).

As noted earlier, 184 of 213 Alaska Native villages face the risk of coastal and riverbank erosion and flooding (Huntington et al. 2012). In 2006, the U.S. Army Corps of Engineers projected costs of more than $200 million to protect shorelines from erosion in the Alaska Native communities of Bethel, Dillingham, Kaktovik, Kivalina, Newtok, Shishmaref, and Unalakleet. The estimated cost of relocating these communities ranged from $20 to $40 million (for Kaktovik) to $100 to $200 million (for Shishmaref) and totaled nearly $500 million (USACE 2006). It is unlikely that the state or federal governments will pay for these relocations (Huntington et al. 2012).

For coastal tribes, sea-level rise, tidal surges, and flooding can damage community infrastructure (Brubaker et al. 2010, SITC 2010). According to the Swinomish climate-change impact assessment (SITC 2009), about 160 residential and 18 nonresidential or community structures on reservation lands, valued at $102 million, are at risk. In Point Hope, Alaska, the estimate for repair and improvement of a flood-damaged road is $2 million (Brubaker et al. 2010). Indigenous communities in coastal Louisiana face the threat of displacement owing to the combined impacts of sea-level rise and environmental changes and contamination associated with the oil and gas industry (Maldonado et al. 2013).

On the Swinomish Indian Reservation, increasing wildfire risk now threatens properties valued at more than $518 million (SITC 2009). Many other tribes in the Pacific Northwest and other regions of the United States are increasingly vulnerable to the threats and stressors of the direct and indirect impacts of wildfire (Lynn 2005).

Climate change is also associated with higher costs of living, including fuel costs, and increases the risk associated with engaging in subsistence practices (Callaway et al. 1999, Cochran et al. 2013). In Alaska, hunters must travel farther, incurring higher fuel and maintenance costs. To lower the risk would require the

purchase of larger boats with larger engines. For example, in the Bering Strait region, decreasing access to fish and marine mammals, coupled with declining income and increasing human population, is making it more difficult for residents to make ends meet. Declining employment, associated wages, high consumer prices, and a lack of public assistance make it difficult for residents to buy food. The rising cost of subsistence activities is also changing the social context of indigenous communities and resulting in a decline in traditional hunting and fishing knowledge. This is causing a "total environment of change," in which "environmental changes and broader socioeconomic challenges are jointly shifting and remaking human-environment relationships" (Moerlein and Carothers 2012: 7).

For coastal Louisiana tribal communities, climate change, government regulation, and colonial legacies are resulting in higher economic costs for, and loss of, subsistence activities.

> Additionally, we are dealing with the increased cost of diesel for the boats combined with the decrease[d] price of the products we catch, such as shrimp. Furthermore, with the lack of freshwater, we have to travel further to our oyster beds, meaning even more diesel used and higher costs. As Maxie Machado of Grand Bayou Village explained, with the lost value of shrimping and changes faced, about 80 percent of the people from our community have had to leave to find work elsewhere. Young adults are moving away because the income used to sustain their families is no longer there (CLTC 2012: 15).

Climate-induced impacts to culturally important traditional foods have economic, social, and cultural impacts.

The harvest of traditional foods is vital for many tribal economies (Callaway et al. 1999, Cozzetto et al. 2013a, Himes-Cornell and Kasperki 2015, Lynn et al. 2013, Whyte in press), thus the climate-induced disappearance, contamination, or disease of culturally important species can have economic impacts. For example, warmer waters in the Northeast have contributed to the bacterial "lobster shell disease" that leaves grotesque scars on lobster shells, making their sale less lucrative for the Pleasant Point Passamaquoddy (Cozzetto et al. 2014b).

For tribes in the Pacific Northwest, salmon fishing is a vital economic activity (Dalton et al. 2013, Dittmer et al. 2013, Grah and Beaulieu 2013, Montag et al. 2014). Salmon populations are being affected by changes in snowpack, precipitation, runoff, and rising water temperatures, threatening tribal fisheries and economies (Dalton et. al 2013, McNutt 2010).

Tribal economies are also affected by reductions in tourism, a weather-dependent activity that is vulnerable to poor and unpredictable weather conditions (Grossman et al. 2012). Tourism is a crucial economic activity for many tribes. Heat and drought are affecting the water quality and quantity of recreational lakes in

Oklahoma (Riley et al. 2012). In Arizona, severe flooding of Havasu Canyon wiped out the economic infrastructure on the Havasupai Reservation, forcing the Tribe to shut down its tourism business (Redsteer et al. 2013a). Impacts to tourism are perhaps most severe for indigenous peoples of Pacific Islands, who gain much of their income from tourism (Grossman and Parker 2012).

Community Infrastructure

Community infrastructure includes roads, utilities, housing, water lines, and public services such as police, fire departments, and medical care, and it supports various community sectors such as health, education, housing, and business. Community infrastructure is vulnerable to landscape hazards, including permafrost thawing, coastal erosion, and, flooding (Ford et al. 2010, Willox et al. 2015). Climate impacts can have compounding consequences, and disruptions in one sector of community infrastructure may cascade into others. This means that, when analyzed together, impacts on community infrastructure are greater than when they are examined independently.

Indigenous communities have differing access to community infrastructure. On many tribal lands, poor economic conditions lead to infrastructure that is inadequate, unmaintained, or altogether absent. Many tribes struggle to provide adequate housing, water, and sanitation services, health services, roads, electricity, and access to healthy foods, both on and off-reservation. According to the Indian Health Service (2013), 12 percent of American Indian and Alaska Native homes are without either a safe and adequate water supply or wastewater disposal. On the Navajo Reservation, 30 percent of residents do not have access to running water and must haul drinking water from springs (Nania et al. 2014). Many rural Alaska communities lack in-home water service, which has been linked to increased rates of respiratory and gastrointestinal tract infections, influenza, and pneumonia (Hennessy et al. 2008). Any climate-related disruption or damage to community infrastructure occurs within these existing inequalities, increasing both the vulnerability of existing infrastructure, and the community resources available for recovery.

Water infrastructure and services—

Water infrastructure refers to the physical structures that access, use, and manage water resources. Water infrastructure is designed for specific conditions and may be unable to accommodate changing climate and hydrologic regimes (Cozzetto et al. 2013b). Climate-induced damage or disruption to water infrastructure can have serious impacts on public health, including the contamination of drinking water, saltwater intrusion, and sewage contamination (Doyle et al. 2013). The lack of

in-home water systems is associated with gastrointestinal infections, pneumonia, skin infections (Hennessy 2008), and lower respiratory tract infections (Gessner 2008). Climate change is projected to increase flooding events (Georgakakos et al. 2014), which can disrupt water services (Cozzetto et al. 2013a, Doyle et al. 2013). On the Crow Indian Reservation in Montana, flooding in 2011 caused water from a wastewater lagoon to overflow into the Little Bighorn River, inundating homes and businesses downstream (Doyle et al. 2013). In the Pacific Islands, flooding, sea-level rise, and severe weather can disrupt water services. For example, in 2010, severe storms on the island of O'ahu in Hawai'i caused multiple severe overflows and pipe breakages (Finucane et al. 2012).

Disruption and damage of water infrastructure and the contamination of water resources can lead to increases in the cost of water services, which can deplete tribal resources (Brubaker et al. 2012). In Point Hope, Alaska, algal booms in lakes and reservoirs have caused increases in the cost and time required to treat water (Brubaker et al. 2010, Cozzetto et al. 2013a).

> The Saint Regis Mohawk Tribe's Water Resource Program is actively working to protect, preserve, and enhance water availability and quality for tribal members in the context of climate change. These actions include the installation of waterline and water-treatment systems, water-quality monitoring, water storage, and swimming advisories in public and family swimming areas (Saint Regis Mohawk Tribe Environment Division 2013).

Transportation—
According to the EPA, climate change "could increase the risk of delays, disruptions, damage, and failure across our land-based, air, and marine transportation systems" (USEPA 2013). On the Navajo Reservation, increasing temperatures could lead to shorter pavement life for airports, roads, and parking lots, increased stress on bridge joints, and delays and increases in the costs of maintenance and construction (Nania et al. 2014, Niemeier et al. 2013). Wildfires and extreme weather events decrease visibility, close roadways, and threaten road, rail, and airport infrastructure (Nania et al. 2014, Niemeier et al. 2013).

For tribes in Alaska, flooding, erosion, and permafrost melting can disrupt transportation and threaten critical infrastructure like runways (Brubaker et al. 2011c, 2014a, 2015; Cochran et al. 2013). The majority of Alaska Native communities are accessible only by plane or boat. Runways are vital for these communities, with aircraft transporting supplies, food, people, and, in the case

of emergencies, evacuation. Damaged roadways can limit access to traditional hunting grounds or food markets (Finucane et al. 2012). Changing conditions can also disrupt ice travel routes for hunting and local travel and make rivers un-navigable (Stepien et al. 2014).

> For the Jamestown S'Klallam Tribe, Highway 101 in Washington is an essential access route for tribal goods and services that are threatened by sea-level rise. To increase transportation resilience, the Jamestown S'Klallam adaptation plan features several strategies, including clearly identified evacuation routes, renaturalizing floodplains, creating roadside bioswales, creating home emergency kits for tribal members, and strengthening partnerships with the Washington Department of Transportation to identify funding to elevate roads and bridges susceptible to flooding (Jamestown S'Klallam Tribe 2013).

Communication infrastructure—
Few studies have focused on the impact of climate change on communication infrastructure (see Nania et al. 2014). However, in a study of the impacts of disasters on urban telecommunication infrastructure, Townsend and Moss (2005) noted three categories of impacts: (1) direct damage to physical infrastructure of communication network, (2) damage to infrastructure supporting the communication network, and (3) congestion or overloading of the communication network during emergency situations (Townsend and Moss 2005). The consequences of communication and infrastructure damage may be particularly dire for tribal communities that are often located in remote areas or with limited financial resources (Brubaker et al. 2015).

Shelter—
Housing and other built infrastructure is often the "first line of defense" against climate hazards (Nania et al. 2014). Built infrastructure can either enhance the adaptive capacity of a community by providing protection from climate impacts, or augment community vulnerability by increasing exposure to climate impacts (Nania et al. 2014). For example, quality shelter can insulate community members from extreme temperatures, flooding, storms, and disease. Climate change threatens built infrastructure in numerous ways from increasing stress on home temperature regulation (Nania et al. 2014) to complete destruction.

Alaska Natives currently experience some of the most devastating climate impacts to shelter and other community infrastructures (Brubaker et al. 2014a; 2015; Willox et al. 2015). Thawing permafrost and erosion along the coast and rivers is causing the destruction of roads, buildings, houses, and harvesting settlements (Bennett et al. 2014b, Brubaker et al. 2015). The loss of infrastructure is exacerbated

by the breakup of sea ice, sea-level rise, and increasingly frequent severe storms (Bennett et al. 2014b). Damage to housing and built infrastructure occurs within existing infrastructural inadequacies like homelessness and a lack of safe housing.

Energy—
Increasing air and water temperatures, decreasing water availability, extreme weather events, sea-level rise, and wildfires all have the potential to disrupt the production and distribution of energy. Flooding, extreme heat, and heavy winds may compromise energy infrastructure and lead to increased power outages (Nania et al. 2014). For example, in 2010, the Cheyenne River Sioux Reservation in South Dakota experienced a massive power outage caused by severe winds from a winter storm (Ortman 2010).

As temperatures rise and heat waves increase in frequency, duration, and extent, more energy will be necessary to maintain household living environments and food storage in the summer (Nania et al. 2014, Riley et al. 2012, SITC 2009). Regionwide increases in energy use may stress systems, especially during heat waves, and could result in brownouts or subsystem failures. Many tribes, such as the Swinomish, do not have adequate alternative power sources to supply backup power to the entire tribal community, increasing the severity of potential outages (SITC 2009).

Climate-Related Disasters

Changing environmental conditions contribute to the increasing frequency and severity of climate-related disasters including drought, flooding, hurricanes, tornados, heat waves, and downpours. There is increasing evidence that links these increases to human-induced climate change (Walsh et al. 2014). American Indian, Alaska Native, and other indigenous communities experience different vulnerability to climate-related disasters based on variation in regional location, cultural practices, and economic and political context. Coastal tribes in Alaska, the Pacific Northwest, and the Southeast are experiencing the loss of subsistence activities, critical infrastructure, and, in some cases are facing potential evacuation and relocation as a result of flooding, erosion, permafrost thawing (in the case of Alaska), and increasing impacts from storms, exacerbated by extensive land loss. Particularly in coastal Louisiana, these issues result from a combination of extractive practices and changing waterways, interacting with climate-change impacts that lead to some of the highest levels of sea-level rise (Laska et al. 2015, Maldonado 2013, Maldonado et al. 2014a).

Although populations around the globe will experience climate-related disasters, disaster vulnerability can be understood as a window into interactions between environmental change and existing political and economic inequalities

(Brooks et al. 2005). Wisner et al. (2004) suggested that disasters are a result of hazards interacting with vulnerability. According to Marino (2015), this model may describe present vulnerabilities, but fails to describe the mechanisms that contribute to vulnerability over time.

The risk of experiencing a climate-induced disaster, and its potential severity, interact with socially constructed vulnerability, and social, economic, and political factors that affect a community's ability to respond to a climate disaster (Brooks et al. 2005). This means that communities with greater access to resources are better able to prepare for, and respond to, climate disasters. Although increased vulnerability can stem from a lack of community resources, it can also result from institutional racism, or "the intentional or unintentional manipulation or toleration of institutional policies that unfairly restrict the opportunities of particular groups of people" (Henkel et al. 2006: 101). For example, Hurricane Katrina magnified and re-created inequalities in New Orleans. Shortly before the hurricane, the city's mayor decided that it was too costly to provide public transportation for storm evacuation, leaving residents without vehicles or funds for travel costs and without an evacuation plan (Reed 2008). The local government distributed DVDs to residents explaining that, in the case of a storm, they would be responsible for their own evacuation, even though a high number of residents did not have access to their own transportation. These policies emphasize individual responsibility without acknowledging the social, political, and economic structures inhibiting people's access to needed resources. Similarly, shortly after Katrina, wealthier evacuees had access to healthcare, clean water, and emergency generators, while evacuees with low incomes were housed in substandard trailer camps (Klein 2007, Reed 2008).

Maldonado (2014: 63) described the conceptualization of climate-related disasters from a political ecological perspective.

> So-called "natural" disasters highlight preexisting socioeconomic inequalities and reproduce those inequalities as the disaster unfolds. Disaster researchers have encouraged a shift from viewing vulnerability to disasters as stemming from abnormal events or geophysical situation of a place to being explained through the everyday social order and systems of domination and inequality.

Disaster vulnerability often illustrates the unequal power relations between groups. In coastal Louisiana, the vulnerability of indigenous communities to land loss, erosion, and toxic pollution has resulted largely from extractive practices of the oil and gas industry that have caused erosion and loss of land between coastal settlements and the Gulf of Mexico. As a result, communities must decide to either

stay in place to protect their remaining ancestral homelands, to relocate as individuals, or, for some communities that have been mostly left out of government-led restoration efforts and have decided that in-situ adaptation is no longer possible, resettle as a community (Peterson and Maldonado 2016). Marino (2012) demonstrated how vulnerability to climate-related disasters and obstacles to relocation are connected with legacies of colonization and ongoing colonial oppression by using a case study of Shishmaref, Alaska. First, local residents are not included in infrastructure planning, resulting in construction locations that are "marginal" and "exposed," providing little protection from the increasing severity of flooding. Second, with imposed sedentarization (the settling of a nomadic population), communities have lost their traditional adaptation strategy of high mobility. Finally, many indigenous communities are subject to external political and economic fluctuations that exacerbate the impacts of climate change. Decisions regarding allocation of funds for community relocation and adaptation occur within governmental institutions detached from tribal communities and without indigenous voices. In 2008, the global economic crisis resulted in limited opportunities for Shishmaref relocation by dramatically reducing available federal funds (Marino 2012). According to Marino (2012: 378):

> The picture that emerges in Shishmaref is one of a long series of government interactions with local residens around development issues that led to vulnerability and are now incapable of creating policy, bureaucratic coordination, and funding to relocate residents away from vulnerable locations.

The political response to climate change in the United States, including efforts to dismiss climate science, have led to resistance in enacting adaptation, including those measures that would support community relocation (Shearer 2012). As such, climate-vulnerable communities must seek assistance from federal agencies with mandates that do not specify climate impacts, including FEMA and the U.S. Army Corps of Engineers. Many federal programs such as FEMA's are designed to offer emergency relief after disasters have occurred, but are unable, owing to restrictive policies, to provide support for long-term environmental change or preemptive action. Although FEMA does offer funding to support relocation, it offers only individual buyouts rather than community-wide support, and options for voluntary relocation are available only to individuals. Using the example of Kivalina, Shearer (2012) demonstrated how the lack of comprehensive displacement and relocation policies can augment vulnerability to climate change. Shearer (2012: 180) argued:

> Without clear relocation policies, the agencies involved have relied upon established protocols and standardized procedures for disaster management and coastal protection, even though these are insufficient to address the full scope of the problem.

FEMA distributes some funds for long-term risk reduction through mitigation grants on the basis of cost effectiveness. With small populations and high costs for mitigation, many indigenous communities often do not qualify. Furthermore, FEMA's two disaster recovery programs and the Hazard Mitigation Grant Program are available only for federally declared disasters, limiting their ability to respond before disasters occur (Shearer 2012). According to the Stafford Act of 1988, FEMA must prioritize "recovery through rebuilding" in the same location (Sec. 504 [a]9D), increasing exposure of vulnerable populations to future climate-induced disasters (Marino 2012).

In 2013, President Obama signed the Sandy Recovery Improvement Act (SRIA). This amendment gives tribal governments the power to request an emergency or major-disaster declaration, or to receive assistance, directly from the White House. Previously, only state governors could make these requests to the president, requiring tribes to make requests through the state. Now, federally recognized tribes have the same status as states when requesting federal disaster assistance, reflecting the sovereignty of tribal governments. This amendment removes barriers for federal disaster funding, as it considers all affected tribal lands following a disaster, regardless of geographic location within state boundaries. For example, in 2009, before SRIA gave tribes the power to request disaster declarations, North Dakota and South Dakota each experienced flooding that affected Standing Rock Sioux tribal lands. Although North Dakota received a presidential disaster declaration almost immediately, South Dakota's declaration was issued months later, and FEMA was able to provide assistance to only part of the Standing Rock Sioux tribal lands (Fugate 2013).

At an international level, UN member states adopted the Sendai Framework for Disaster Risk Reduction 2015–2030 (SFDRR) in March 2015. The framework shifts the emphasis from disaster management to management of disaster risk and focuses on preventing new risk, reducing existing risk, and strengthening resilience. Among other issues, the framework articulates the need for improved understanding of disaster risk and risk exposure, vulnerability, and hazard characteristics, and resilience of health infrastructure, cultural heritage, and workplaces (ISDR 2015). However, this framework has been critiqued for being top-down and

government-centric, and for minimizing the role of local actors and community-owned approaches (Oxley 2015, Tozier de la Poterie and Baudoin 2015). Tozier de la Poterie and Baudoin (2015) argued that SFDRR has an "expert-driven narrative" that privileges technological solutions and Western science over community involvement and traditional knowledge (Tozier de la Poterie and Baudoin 2015). Climate-change-related cumulative health problems are and will continue to affect indigenous communities. Many tribes have the potential to develop or restructure their health care programs (Allison et al. 2007), but few tribal governments or Indian Health Service programs are strategically preparing for climate change impacts to their communities.

As a response to threats of coastal and riverine erosion, the Alaska Native village of Shaktoolik, assisted by the University of Alaska, developed a community-led adaptation plan. The plan outlines the community's decision to "stay and defend," meaning that they have opted not to relocate, and instead to fortify their community to climate impacts including harsher storms and erosion. Their plan includes nine initiatives that focus on the protection of human life, buildings, and infrastructure. Understanding limitations in funding, the people of Shaktoolik chose these initiatives because they are cost-effective and promote the use of local labor and materials (Johnson and Gray 2014).

Climate-Induced Displacement

According to the IPCC, climate-induced environmental changes will displace 150 million people by 2050. Other projections indicate that this number could be far greater. In this section, we first describe historical accounts of relocations of indigenous peoples during the colonial period. Next, we examine varying perspectives on how indigenous communities are reacting and responding to climate-induced displacements. Because there are ongoing debates regarding the terminology that should be used for climate-induced displacement, we offer brief definitions and discussions of these associated terms.

H**istorical relocations of indigenous communities in the United States**—Throughout the history of the United States, government-mandated relocations for geopolitical or infrastructure development had devastating consequences on communities (Bronen 2015b). Since first contact with European colonists, tribes endured the cession of tribal land and displacement by settlers, resulting in the loss

of culture, collective identity, livelihoods, and the dramatic loss of lives (Miller 2011). One of the largest eras of relocation for indigenous communities occurred when Andrew Jackson signed the Indian Removal Act of 1830, resulting in the removal of indigenous peoples living east of the Mississippi River from their ancestral homelands. This law forced the Cherokee, Choctaw, Creek, Chickasaw, and Seminole Nations to cede their lands to the United States and to be relocated west of the Mississippi River. Known as the Trail of Tears, this 1,200-mile government-mandated relocation took 9 months, during which tens of thousands of indigenous peoples died as a result of food shortages, disease, dehydration, and exposure (Bartrop 2007, Blackburn 2012, Native Voices 2015). For those indigenous peoples who survived, relocation had devastating consequences on their livelihoods, collective identities, and culture (Akers 1999).

Relocation of indigenous communities has had devastating consequences on livelihoods, collective identities, and culture.

In 1933, less than 100 years after the Indian Removal Act, the federal government implemented the Nation's largest river development program, the Tennessee Valley Authority (TVA). The TVA authorized the construction of dams to control flooding in the Tennessee and Mississippi River basins (TVA 1961). To construct the Norris Dam, the federal government used eminent domain to purchase land in five Tennessee counties, resulting in the displacement of 2,700 families. These families were forced to relocate to populated areas, resulting in loss of subsistence lifestyles and widespread poverty (McDonald and Muldowny 1982). The TVA continued the displacement of tribes by destroying their cultural sites and cultural heritage. The creation of the Tellico Dam and flooding of the Little Tennessee Valley threatened burial sites of the Eastern Cherokees, who fiercely resisted the project (Riley 2002, Whitt 2009). In the case Sequoyah v. Tennessee Valley Authority (1979), medicine man Ammoneta Sequoyah argued that destruction of this burial site would destroy "the knowledge and beliefs of the people who are in the ground and destroy what they have taught" and he would lose his knowledge of medicine (Riley 2002, Whitt 2009).

The 1974 Navajo-Hopi Land Settlement Act, known as the Relocation Act of 1974, resulted in the relocation of more than 10,000 Diné (Navajo), many of who experienced physical, mental, spiritual, and emotional suffering. At a public hearing held by the Navajo National Human Rights Commission, tribal members who had been relocated described the impact relocation had on their livelihoods, citing the breakdown of families, mental health issues, alcoholism, cultural deterioration, unemployment, and poverty. One person recalled her experience as a child:

> I remember getting off the bus at a place that looked familiar but nothing was there. They bulldozed over the house, the hogan, the corral and the livestock were gone. The land was completely cleared and as I stood there the bus driver drove off. Everybody was gone and everything was gone (Yazzie et al. 2012: 6).

The Diné who accepted relocation packages say they were misled and misinformed, "they told us we'd have all kinds of luxuries. They said they would take care of us. They lied to us" (Yazzie et al. 2012: 76). Those who stayed experienced constant anxiety, fearing that they would be physically removed from the land.

These examples demonstrate the enduring social and cultural impacts of forced displacement on individual and community lifeways. As asserted by Marino (2015: 94):

> The last one hundred years of displacement and resettlement, particularly of indigenous and marginalized groups, have mostly been a failed experiment in government-driven social engineering that resulted in further impoverishment and social disarticulation of moving populations.

To avoid these, and other, negative consequences, approaches to relocation must be grounded in a human-rights-based framework.

Relocation—
The United Nations High Commissioner for Refugees defines relocation as the movements of people that are instigated, supervised, and carried out by state authorities (Weerasinghe et al. 2014). Bronen (2015) presented an alternative definition of relocation as the rebuilding of livelihoods, houses, public infrastructure, and social networks in another location (Bronen 2015). Relocations can be either temporary (called evacuations), or permanent (called resettlement), and are considered a form of displacement (Weerasinghe et al. 2014). Relocations that occur before a disaster, called preventive relocations or planned relocations, can be an important disaster-risk-reduction tool that saves lives and offers long-term protection (Bronen 2015). Community relocations occur when places cannot be protected by disaster risk strategies and will become uninhabitable (Bronen 2014b). Tribal, state, and federal efforts to conduct climate risk and vulnerability assessments can inform decisions about relocation.

Displacement—
Bronen (2014b) presented three categories of climate drivers of displacement: extreme weather events, slow-onset environmental changes, and the combination of extreme weather events and slow-onset environmental change. These drivers result in distinct patterns of human migration that differ based on the period of migration and the demographics of the population. However, relocation, displacement and climate-induced migration, also called "climigration," present severe challenges to community resilience. A key theme in the literature is how to maintain community resistance and resilience in the context of climate-change-induced displacement.

Climate-induced migration—
Migration refers to the movement of populations. Bronen (2010) differentiates between migration that is caused by random catastrophic environmental events and climigration, the forced migration caused by climate-induced ecological changes. According to Bronen and Chapin (2013: 9320), climigration refers to the specific type of population displacement that occurs when relocation is required to protect a community from climate-induced environmental changes that "alter ecosystems, damage or destroy public infrastructure, and repeatedly endanger human lives." Bronen and Chapin (2013) argued that climigration relocations provide the opportunity for planned retreat. In the context of climigration, community relocations include rebuilding public infrastructure, housing, and livelihoods away from risky areas (Bronen and Chapin 2013).

Resilience—
Within the climate-change literature, resilience is often contrasted with vulnerability in describing the adaptive capacities of communities experiencing climate-change impacts. Tanner et al. (2015) presented a livelihood-resilience approach, grounded in a livelihood framework that focuses on people, and their ability to sustain livelihoods, as central actors within adaptation policy and practice. According to Tanner et al. (2015: 4), this perspective does three things (emphasis in original):

> First, it prioritizes **human agency**, and our individual and collective capacity to respond to stressors. Second, by drawing on **rights-based frameworks**, it helps establish a normative and legal consideration of justice in disaster-risk reduction and adaptation. Third, by challenging normative assumptions about resilience as stability and the desirability of "bouncing back'" it prioritizes individual and collective capacities for fundamental **transformation** (Tanner et al. 2015).

We use this livelihood-resilience approach to conceptualize the meaning of resilience in the contexts of displacement, relocation, and climigration.

Although federal and state agencies have a number of tools to facilitate protection in place and managed retreat, there are limited tools available for community relocations. Bronen (2015) discussed the current governance institutions for protection in place, including engineered structures, building codes, post-disaster relief, and managed retreat. However, these tools may offer only temporary protection as places become uninhabitable or disappear permanently because of erosion, flooding, and sea-level rise. Ongoing efforts to protect people in place may result in practices that re-create or increase vulnerabilities and prevent long-term planning that enhances resilience and adaptation (Weerasinghe et al. 2014). To enhance community resilience, it is necessary to understand rates of environmental change, and, when necessary, plan for preventive relocation before land disappears (Bronen 2015).

Currently, there are no governance frameworks, in the United States or abroad, that evaluate climate-change impacts and determine when a community can no longer be protected in place (Bronen 2014a; 2014b; 2015; Weerasinghe et al. 2014). There are also no institutional mechanisms that determine when a preventive relocation should occur, who makes the decision to preventively relocate, or how the decision should be made (Bronen 2014b, 2015). It is possible that, in efforts to protect communities from climate impacts, governments may mandate preventive relocations without the consent of a community (Weerasinghe et al. 2014). Such government-mandated relocations are extremely harmful, weakening social, cultural, and political institutions, disrupting subsistence and economic systems, damaging kinship ties, and even resulting in deaths in the relocated population (Bronen 2015, Mobley 2012).

Adaptation and human rights—

Given the historical and contemporary forced relocations of indigenous peoples, indigenous communities must be empowered to make their own decisions regarding relocation (Marino 2012, 2015). It is essential that relocation policy frameworks be created based on human rights principles (Bronen 2011, 2014b, 2015; Tanner et al. 2015). Relocation should be considered only after all possibilities for staying in place [e.g., resistance] are exhausted and should not be used as a way to force communities off of their land. According to the UN Declaration on the Rights of Indigenous Peoples (UNDRIP 2007: Art: 1), "Indigenous peoples possess collective rights indispensable for their existence and well-being, including the right to collective self-determination and the collective rights to the lands, territories, and natural resources they have traditionally occupied and used." In the context of

climate change, the right to self-determination means that people have the right to make decisions regarding adaptation strategies and the right to make fundamental decisions about when, how, where, and if relocation occurs (Bronen 2011, 2014b, 2015). This ensures that the communities affected by the relocation drive decision-making. It can also help to avoid the negative consequences associated with forced relocation, like poverty and the destruction of social networks, by placing control with those who understand a community's economic, social, and physical contexts (Bronen 2015b). The right to self-determination in a climate-change context is operationalized when people have the capacity to assess and document environmental changes, sociological effects, and vulnerabilities caused by climate change. The ability of this community-based process to foster human rights depends on the capacity of governance institutions to respect indigenous and local rights, collaborate, be transparent in decisionmaking, and be inclusive of all sectors of society (Bronen 2015).

Adaptive governance response—
To address the lack of governance frameworks and minimize the negative consequences of government-mandated relocation, Bronen (2015) proposed the creation of an adaptive governance framework, grounded in human rights, that allows government institutions to respond dynamically to environmental changes (also see Bronen 2011; 2014b; Bronen and Chapin 2013; Rising Voices 2014).

Dynamic adaptive governance frameworks enable consideration of a range of options to respond to community needs.

> An adaptive governance relocation framework would incorporate all of the institutional mechanisms to protect people in the places where they live and also create new mechanisms to implement a relocation process so that national, state, local, and tribal governments can dynamically shift their efforts from protection in place to managed retreat and community relocation (Bronen 2015: 35).

Unlike static frameworks developed in response to current conditions, dynamic frameworks give communities a variety of adaptation strategies and options. Dynamic adaptive governance gives institutions a range of options to respond to the needs of communities, including disaster relief, hazard mitigation, protection in place, socioecological assessments, and relocations (Bronen 2015, Bronen and Chapin 2013). This framework includes the design of community-based social-ecological monitoring and assessment tools that creates multilevel and multidisciplinary, community-led knowledge production. The framework facilitates a collaborative decisionmaking process between local communities and technical experts to determine if, and when, a community should relocate (Bronen 2015).

The tool is based on the experiences of the Alaska Native villages of Shishmaref, Kivalina, and Newtok, whose monitoring and assessments were used to gain governmental technical assistance and, based on this assessment, community members decided that relocation was their only long-term adaptation strategy. According to Bronen (2015: 35) "community-based integrated assessments can foster empowerment, promote human rights protections, and encourage transparent decisionmaking processes."

Bronen (2013) argued that the first step to overcoming barriers to relocation is for the U.S. Congress to amend disaster-relief legislation so that it enables communities to use existing federal and state funding to construct infrastructure at sites outside of disaster areas. Bronen (2014) also suggested that Congress establish a governance framework that allows communities to relocate when they are no longer protected by traditional erosion- and flood-control devices.

When stay-in-place options are exhausted, approaches to relocation should be grounded in a human rights frameworks that protects the right to self-determination, and prevents forced relocation and the movement from one exposed location to another (Bronen 2011, Cochran et al. 2013, Maldonado et al. 2013). Bronen (2011) offered Guiding Principles of Climigration, a legal and institutional framework grounded in a human-rights approach to relocation. This perspective is built on the theoretical perspectives of refugee law, the Universal Declaration of Human Rights, the Guiding Principles on Internal Displacement, and the Universal Declaration on the Rights of Indigenous Peoples, while addressing the unique economic and political context of climigration (Bronen 2011). Bronen's Guiding Principles ensure that a group's cultural, social, and economic human rights are protected during displacement and resettlement. Bronen suggested that tribal communities decide if relocation is an appropriate adaptation strategy and be key leaders in relocation decisions. Relationships are central to cultural identity, therefore relocation should keep tribes and families intact and tribes must determine how to maintain their sociocultural institutions. Furthermore, understanding the rights and ability of tribes to continue their relationship with a place after being relocated should be explored.

Subsistence rights and the customary communal rights to resources must also be protected (Bronen 2011). Bronen's Guiding Principles also affirm access to safe and sanitary housing, potable water, education, and other basic amenities. Relocation must not diminish quality of life and should include opportunities for sustainable development. With this, relocation should enhance community resilience by addressing socioeconomic issues contributing to vulnerability (Bronen 2011).

After experiencing several extreme weather events, thawing permafrost, and accelerated erosion, the residents of the Alaska Native village of Newtok voted to relocate 9 miles to the south. The Newtok Traditional Council negotiated a land-exchange agreement with the U.S. Fish and Wildlife Service and obtained the site, which they named Mertavik. Every aspect of the relocation process has been guided by a set of principles based on the Yup'ik way of life (Bronen 2014). Bronen's guiding principles (2014) include:

- Remain a distinct, unique community—our own community.
- Make decisions openly and as a community, and look to elders for guidance.
- Build a healthy future for our youth.
- Our voice comes first—we have first and final say in making decisions and defining priorities.
- Development should reflect our cultural traditions; nurture our spiritual and physical well-being; respect and enhance the environment; be designed with local input from start to finish; be affordable for our people; hire community members first; use what we have first; and use available funds wisely.

In 2013, Displacement Solutions' Climate Change and Displacement Initiative (CCDI) Climate Displacement Law Initiative adopted the Peninsula Principles, a major international soft-law standard on climate displacement. The Peninsula Principles outline an adaptive governance framework based in human rights.

Department of Housing and Urban Development principles for relocation—

In response to recommendations made by the Task Force on Climate Change Preparedness and Resilience, the Department of Housing and Urban Development (HUD) is developing cross-agency principles for climate-related relocation and managed retreat from high-risk areas. According to the White House, these principles are designed to strengthen the consideration of equity and other issues when using HUD funds for voluntary relocation of communities. As part of this effort, HUD plans to engage in a government-to-government consultation with Arctic coastal villages as a model for fostering future collaboration with other regions (White House 2015).

Fossil-Fuel Extraction, Transport, and Export

Indigenous populations are experiencing environmental change associated with the development, extraction, and transportation of fossil fuels. Many of these practices are profit-driven and executed by nontribal private entities that consume resources in unsustainable ways, threatening indigenous lands, resources, and livelihoods. At the same time, some tribes rely on the revenue and employment associated with fossil fuels and see expanding production as necessary to enhance well-being in their communities (Miles 2005). In this section, we discuss the negative impacts experienced by tribes associated with development in general, and more specifically with oil and gas development. We examine the negative impacts of the extraction, transportation, and export of fossil fuels, and the actions taken by some tribes to mitigate these impacts. We conclude with contrasting perspectives and voices of tribes that see fossil fuels as an important resource for their communities.

Development—

For many tribes, development projects, including dams, transportation infrastructure, and natural-resource extraction, have been associated with the dispossession and destruction of tribal resources, lands, and ways of life (Hoover 2013, Oliver-Smith 2009). Industry development has also contributed to the displacement of tribal communities. Development-forced displacement and resettlement, known as DFDR, is a form of internal displacement that occurs for a "greater" economic good, and the government that is responsible for the relocation is also responsible for the well-being of the removed population. In the context of development, the interests of the federal government have often clashed with the interest of affected indigenous peoples. In these cases, institutionalized racism has often affected decisions about land ownership, participation, consultation, and decisionmaking (Oliver-Smith 2009).

In addition to displacement, industry development is also associated with the contamination of waterways and traditional food sources relied upon for subsistence. As discussed by Hoover (2013), a Superfund site upstream from the Mohawk community of Akwesasne was responsible for the contamination of fish, wildlife, and breast milk with PCB, dioxin, and mercury. In response, the adjacent St. Regis Mohawk Tribe issued advisories urging community members to limit, and in some cases cease, their consumption of fish, a central part of culture, economy, and subsistence. The contamination and associated restrictions had negative impacts on the fishing economy, tribal health, and cultural transmission. Many feared that fish-related language and culture would be lost (Hoover 2013).

Oil and gas industry—
Many tribes have experienced negative impacts associated with development (Hoover 2013; Maldonado 2014a, 2014b; Murphy 2013; Oliver-Smith 2009). The development of the oil and gas industry has had devastating consequences for tribes and other local communities. The Louisiana coastal zone has experienced some of the worst impacts associated with oil and gas development (CLTC 2012; Houck 2015; Maldonado 2012; 2014a). Since fossil-fuel extraction began in the 1920s, 12 billion barrels of oil and 100 trillion cubic feet of natural gas have been extracted from the Louisiana coast (Houck 2015). To access and transport these fossil fuels, the industry dramatically altered the ecosystem, dredging canals and building pipelines through coastal wetlands. These alterations increased the flow of water from the Gulf of Mexico, causing erosion, land loss, and saltwater intrusion. In addition, the extraction of natural gas and associated water has resulted in rapid subsidence. As asserted by Houck (2015: 215), "oil and gas development had put Louisiana's coastal wetlands in a double bind, torn apart on top and undermined from below." Research estimates that between 36 and 89 percent of the coastline has experienced erosion and loss related to oil and gas industry development (Houck 2015).

Louisiana coastal-zone oil and gas development has altered the ecosystem, causing erosion, land loss, and saltwater intrusion.

Maldonado (2014a) discussed the impact of the oil and gas industry on Louisiana's coastal landscape and tribal communities (see also CLTC 2012, Peterson and Maldonado 2016). Oil extraction and exploration, and the privileges afforded to corporations, have resulted in coastal Louisiana becoming an "energy sacrifice zone." In an energy sacrifice zone, potential oil resources are valued more than the human lives (see Buckley and Allen 2011). In addition to environmental change and coastal land loss caused by oil pipelines and canals, tribal lands have been lost to land-grabbing techniques by state-backed oil companies and private land developers, resulting in processes of displacement and forced relocation. As one tribal member stated:

> "Oil companies got down there and started building canals everywhere, that's when the land started going away" [Maldonado 2014a: 65].

It is likely that oil and gas related development has resulted in the contamination of tribal resources (CLTC 2012, Maldonado 2014a, 2012; Murphy 2013). Byproducts of the industry can contaminate soils, food sources, and drinking water (Houck 2015, Murphy 2013). Although tribal communities may experience environmental and bodily changes that raise concern about toxic byproducts of oil and gas development, contamination can be difficult to prove (CLTC 2012, Maldonado 2014a). Their marginalized position leads to experiences of what Singer (2010) defined as **toxic frustration** (CLTC 2012, Maldonado 2014a).

> Individuals who experience toxic frustration feel reasonably certain that the environment is unhealthy, point to the huge manufacturing plants and agribusinesses around them as the primary causes of their environmental suffering, but also believe there is not much they can do about it given their socioeconomic status and the unresponsiveness of the local or state government (Singer 2010: 34).

According to Peterson and Maldonado (2016), coastal Louisiana residents experience toxic uncertainty resulting from unknown toxins used in fossil-fuel extraction and oil spills like the 2010 BP Deepwater Horizon disaster. Peterson and Maldonado (2016) used the case of coastal Louisiana to demonstrate that it is not just a singular disaster event that leads to community devastation, but rather the layering of disasters and socially constructed vulnerabilities on top of existing economic and political forces. As a sacrifice zone, local and tribal communities in coastal Louisiana experience elevated risks from economic and political forces associated with the oil and gas industry.

The Aamjiwnaang First Nation, a small Ojibwe group, lives along the St. Clair River between Port Huron, Michigan, and Sarnia, Ontario. This area is known as "chemical valley" and is home to Shell, Sunoco, and Imperial Oil refineries. In the 1970s, commercial fishing was banned because of mercury contamination, and some members of the Aamjiwnaang, along with residents of several other communities, were diagnosed with a form of mercury poisoning called Ontario Minamata Disease. However, the impacts of chemical exposure are not necessarily experienced immediately upon exposure. According to Murphy (2013: 110–111):

> Chemical injury is not just displaced spatially with super stacks, toxic trading and selective plant placement, but also that chemical injury is displaced temporally, such that accountabilities exceed the scope of individual lives, bioaccumulating or persisting over time, across regulatory regimes, beyond research grants and into the conjectural future.

The Aamjiwannag experience reproductive disorders, cancers, and other negative health impacts that result from latent responses to past exposure, or what Murphy (2013: 15) asserted is a "chemical manifestation of ongoing colonial violence."

Coal industry—

Although there has not been substantial research on the impacts of coal extraction on tribes, a number of recent reports have discussed coal impacts on environmental health (Bonogofskey et al. 2015, LaFontaine et al. 2012). Coal dust containing toxic heavy metals like mercury can cause increased rates of asthma (Power Past Coal 2015). Coal-fired power plants produce coal ash, a solid waste containing mercury, lead, and arsenic. Coal mining affects the quality and quantity of water resources. Although some coal ash is recycled into concrete, more than half is dumped into ponds, mine pits, lagoons, and other surface facilities (Olsen 2013). Leaching ore, waste rock, and other byproducts pollute surface and ground waters (Bonogofsky et al. 2015). The cutting and draining of aquifers changes surface water, depletes springs, and minimizes flows in creeks and streams. Coal mining is also associated with destruction of local ecosystems, including the mortality, disturbance, and displacement of wildlife populations and the loss of native plants. Wildlife mortalities are caused by development, mining equipment, and increased traffic. Wildlife that is displaced must move into areas that are already inhabited by other animals and must compete with existing populations for resources (Bonogofsky et al. 2015). Coal transportation creates coal dust and diesel exhaust from coal trains, reducing the air quality and contaminating waterways with mercury. The increased barge activity at export terminals can damage and destroy coastal ecosystems and fisheries (LaFontaine et al. 2012).

Although the United States has reduced its dependence on coal over the last decade, there has been a recent push by coal companies—namely Peabody Energy and Arch Coal—to export coal to Asian markets (LaFontaine et al. 2012, Olsen 2013). These coal development projects have been critiqued by tribes and environmental groups for issues associated with coal extraction, transportation, and export (Bonogofsky et al. 2015, LaFontaine et al. 2012, Olsen 2013, Power Past Coal 2015). Proposed projects include Arch Coal's Otter Creek Coal Mine in the Powder River Basin in southeastern Montana and northeastern Wyoming. Some Northern Cheyenne tribal members have spoken out on the devastating consequences the proposed project would have on tribal health, culture, and economy (Olsen 2013). The Oglala Lakota Tribe passed a resolution opposing the Otter Creek coal mine, asserting that the mine threatens culturally important sites and burial grounds (Olsen 2013). These projects would have vast environmental, community, and cultural health impacts at extraction sites, and along transport routes and at export terminals. In Washington, export terminals threaten important tribal cultural and economic resources (Olsen 2013, Yardley 2015). The proposed Cherry Point end terminal would be built on a Lummi Nation burial site and state aquatic reserve and the Longview terminal

would affect salmon, steelhead, and smelt habitats in the lower Columbia River (Olsen 2013). Critics also maintain that exporting coal contributes to climate change by encouraging Asia to continue its reliance on the fossil fuel rather than encouraging a shift to alternative options (LaFontaine et al. 2012).

Transport and export of fossil fuel on Native lands—
Tribes have been vocal in their opposition to the transportation of fossil fuels across tribal lands and the export of fossil fuels from terminals in the Pacific Northwest to markets in Asia. Tribes in the Northwest and the Dakotas have expressed concern about the transportation of Bakken crude oil by train across tribal lands. Bakken crude oil is unstable and can cause explosions and environmental contamination if a train is derailed. On May 6, 2015, a Bakken crude-hauling oil train exploded in North Dakota, prompting the evacuation of the neighboring town of Heimdal. In response to this disaster, Fawn Sharp, Quinault Indian Nation president, made the following statement:

Tribes have opposed transportation of fossil fuels across tribal lands and proposals to transport coal to Asia.

> This was just the latest in a series of oil train derailments that have resulted in crashes, followed by explosions, mountains of thick, black, toxic smoke and inevitable spills of poisonous oil that at some point make their way into water systems, streams, rivers or marine waters… Let there be no doubt. These trains are dangerous, and we are seeing more and more of them on our tracks all the time (ICTMN 2015).

Sharp continued by outlining the concerns of tribal communities, including the protection of communities, treaty rights, and the role of fossil fuels in environmental degradation:

> Tribes are very concerned about them for many reasons. Not only do they jeopardize our citizens, because they are explosive and too heavy for the tracks they travel on, but also the oil that inevitably spills from them poisons our treaty-protected waters and aquatic resources… Also, fossil fuels are the primary cause of climate change. We all need to make some important decisions about the future. Do we accept the major expansion of these poisonous fuels and the impacts they have on our environment, or do we opt to be good stewards of the land and work to phase them out and replace them with clean energy sources and wiser choices? [ICTMN 2015:1].

The protection of treaty rights also is a concern for The Columbia River Inter-Tribal Fish Commission (CRITFC), which opposes proposals from the energy industry to export coal form Powder River Basin to Asia through ports in the Columbia Gorge. CRITFC opposes these projects, claiming they threaten treaty rights by intensifying stresses on fishing populations and sites.

> All of these projects will affect the Columbia and those who depend on it, creating environmental injustice as the burdens of the projects fall on those who will reap the least benefits (Columbia River Inter-Tribal Fish Commission 2015).

Some tribes are evoking tribal sovereignty and treaty rights to limit the transportation and export of fossil fuels in order to mitigate the risks associated with the transportation of fossil fuels. On April 7, 2015, the Swinomish tribe filed a lawsuit against Burlington Northern Santa Fe (BNSF) Railway in an attempt to prohibit the transport of Bakken crude oil across reservation lands. Swinomish tribal chairman Brian Cladoosby said (Walker 2015):

> We told BNSF to stop, again and again… We also told BNSF: Convince us why we should allow these oil trains to cross the reservation. And we listened for two years, even while the trains kept rolling. But experiences across the country have now shown us all the dangers of Bakken crude. It's unacceptable for BNSF to put our people and our way of life at risk without regard to the agreement we established in good faith.

Tribes have also attempted to restrict the transportation of fossil fuels through legal dealings with the U.S. Department of Transportation (DOT). In 2015, the Columbia River Treaty tribes and the Northwest Treaty Tribes submitted appeals to the Pipeline and Hazardous Materials Safety Administration (PHMSA) concerning new regulations on the transportation of hazardous materials. The Treaty tribes argued that DOT did not meet requirements for formal tribal consultation mandated by Executive Order (E.O.) 13175 because of unique and substantial effects on the tribes and their interests. The tribes asserted that, "[h]ad PHMSA consulted with the Northwest treaty tribes, it would have learned of the tribal and federal interests in their collective usual and accustomed fishing areas and potential impacts resulting from the proposed Tank Car Rule." PHMSA denied the treaty tribes' appeals, claiming that regulations did not have "unique" or "substantial effects," and therefore formal consultation was not mandated. According to the ruling:

> PHMSA believes that these regulations work to the benefit of all communities and areas affected by the rail transportation of flammable liquids. For this reason, PHMSA affirms that the impact of the final rule is not "significant" or "unique" to communities or resources under the jurisdiction of tribal governments (20).

> PHMSA has determined that this rulemaking does not significantly or uniquely affect tribes, and does not impose substantial direct effects of costs on such governments… The decision to forgo tribal consultation was the lack of direct tribal impacts (21).

In another action, the Lummi Nation invoked its treaty rights to block the Gateway project, which proposes the creation of six coal export terminals in Oregon and Washington. The 1855 Treaty of Point Elliott gives the Lummi access to "usual and accustomed" fishing areas. The Lummi claim that the Gateway project would damage fishing grounds and salmon and steelhead populations, resulting in a violation of the treaty. As a result, the U.S. Army Corps of Engineers is conducting an environmental review of the project to assess potential environmental consequences (Yardley 2015).

Tribal support for fossil-fuel development—
Not all tribes are united in their opposition to coal development (Caufield 2015). The Navajo and Crow Nations have long depended on revenue from coal mining, to provide both Nations with over half of their nonfederal funding (Caufield 2015). The Crow and Navajo experience unemployment rates of almost 50 percent, and existing coal production plays an important role in tribal employment. As such, the expansion of coal development provides an opportunity for increased tribal revenue and employment for tribal members. The Crow Nation signed an agreement with Cloud Peak Energy to allow the mining of 1.4 billion tons of coal on the reservation. The tribe planned to export coal to Asia through the same Gateway terminal contested by the Lummi Nation and other Northwest groups. In April 2015, the Senate Committee on Indian Affairs on the Crow Indian Reservation held a hearing entitled, "Empowering Indian Country Though Coal, Jobs and Self-determination" to allow individuals to speak about the impact of coal and proposed EPA regulations on their livelihoods. In response to the controversial Gateway Pacific Terminal in Washington, Crow Chairman Old Coyote stated, "we believe this is environmentally responsible and until someone comes up with another way to feed my people, the Crow Tribe will continue to mine coal," adding that "a war on coal is a war on the Crow people" (Caufield 2015: 1). This example demonstrates the complexities associated with coal development, extraction, and transportation, and the differing perspectives of tribal communities. According to Lummi tribal council member Johnny Felix, "Everyone says it's the Lummi against Crow… It's not. It's not a tribe against a tribe. It's a resource against a resource. That's our resource — out there in the water. And their resource is coal" (Yardley 2015: 1). This demonstrates that fossil-fuel development on tribal lands can result in political discord between tribes. Regardless of the economic benefits, political discord can also occur within a tribe

if some members feel that energy development conflicts with traditional values and threatens the intergenerational transmission of tribal culture and identity (Necefer 2014). It is likely that such inter- and intratribal conflicts will continue as tribes are forced to leverage between traditional resources and economic well-being.

Tribal Approaches to Climate Change: Adaptation and Mitigation

The resilience of indigenous communities facing threats of climate change is strengthened when indigenous peoples shape climate policies, are included in natural resource management, strengthen tribal economies, and engage in sustainable development (Chief et al. 2014). Tribes must have access to the financial, technical, and other resources necessary to assess and adapt to climate change. Additionally, tribes should be supported in efforts to reduce GHG emissions through investments in renewable energy and energy efficiency. Recently, there have been efforts to increase the inclusion of indigenous voices in climate change and resource management decisions. One theme of this literature is the importance of partnerships and collaboration with indigenous communities and nontribal governments and organizations in the creation of sustainable adaptation strategies (Cochran et al. 2013, Lynn et al. 2013, Maldonado et al. 2013, Whyte 2013, Wildcat 2013). The U.S. government has a trust responsibility to federally recognized tribes to ensure the protection of, and access to, tribal trust lands, including reservation land and off-reservation land held in trust (Salazar 2009). As mandated by Executive Order 13175 (2000), interactions between tribes and the federal government should be conducted on a government-to-government basis, based on consultation and respectful dialogue (Lynn 2011).

Adaptive Capacity and Adaptation

In recent years, there has been increasing attention to strategies that aim to cope with changing environmental conditions. According to the IPCC, adaptation strategies are defined as:

> A general plan of action for addressing the impacts of climate change, including climate variability and extremes. Such strategies include a mix of policies and measures that have the overarching objective of reducing vulnerability to climate change impacts (Mimura 2014: 873).

Climate-change adaptation plans are being developed by communities in the United States (and abroad) to assess vulnerability and identify strategies for adaptation. Although there are obstacles to the adaptive capacity of indigenous communities, there are also many factors that contribute to their adaptability and

resilience, including traditional knowledges, cultural practices, capacity for natural resource management, proactive initiatives for the control of invasive species, strong external scientific networks, tribal awareness of climate change (Gautam et al. 2013), and intertribal collaboration. These factors contributing to their adaptive capacity demonstrate why indigenous communities must lead their own processes to understand climate impacts and develop adaptation strategies (Chief et al. 2014, Cochran et al. 2013, Halofsky et al. 2015: 13–15, Maldonado et al. 2013, Reid et al. 2014). Local values and traditional knowledges are also critical in the creation of culturally appropriate adaptation strategies (Chief et al. 2014, Grossman et al. 2012, Maldonado et al. 2013, Reid et al. 2014, Whyte 2015, Wildcat 2009). According to Reid et al. (2014):

Local values and traditional knowledges are critical in the creation of culturaly appropriate adaptation strategies.

> Incorporating local values into the climate-change planning process in a structured way and effectively using local knowledge not only improves the identification of priority actions for climate change adaptation, but also supports successful implementation.

McNeeley and Lazrus (2014: 517) described how culture and worldview impact different approaches to climate change mitigation and adaptation. They argued that climate change adaptation requires:

> …an understanding of people's cultural worldviews about social organization and nature, which determines how they see the climate system "working;" and participatory, community-based approaches to analysis to understand the nuances of the relationship between culture, climate change, and adaptation strategies.

Approaches to climate change that are rooted in traditional knowledges and values allow for adaptation strategies that are holistic and comprehensive. Reid et al. (2014) described four ways in which tribes and indigenous communities respond to climate change: research collaborations, information campaigns, restoration efforts, and public awareness. However, indigenous approaches to adaptation are not universal and there can be different approaches within the same tribe. Adaptation strategies can be pursued through more formalized avenues, like the drafting of climate-change impact assessments and adaptation plans, or in less formal, and even unconscious, ways (Maldonado 2014b). Maldonado (2014b) discussed how adaptation occurs in an everyday way, consciously and unconsciously (see also Maldonado 2015). She described how residents adapt in multiple ways, through the rebuilding of subsistence livelihoods, cleaning up and returning to homelands after disasters occur, and partnering with federal and university researchers (Maldonado

2014b). Whyte et al. (2014) explored the challenges that tribes face in creating adaptation plans in contexts of uncertainty and in ways that meet political, cultural, scientific, social, jurisdictional, and legal goals.

The role of federal, state, and local policy in supporting or undermining the adaptive capacity of indigenous communities is significant, and special attention must be paid to policy decisions that affect the ability of communities to adapt to climate change (Nakashima et al. 2012). Chief et al. (2014) described the importance of the government-to-government relationship in ensuring that tribes are formally consulted on the management of culturally important species and that management plans reflect tribal priorities and concerns. There are policies and administrative mechanisms that can help achieve a meaningful government-to-government relationship, including Executive Order 13175 (2000) that demands federal agency accountability in consulting and coordinating with federally recognized tribes, and the Tribal Forest Protection Act (2004), which authorizes the Secretaries of Agriculture and Interior, respectively, to consider contracts or projects proposed by tribes on Forest Service or Bureau of Land Management (BLM) lands that border or are adjacent to Indian Trust Land (PL 108-278, 2004), or department-specific orders addressing the impacts of climate change to tribes or tribally valued natural and cultural resources (Salazar 2009).

For tribes, different laws, policies, and regulations can obstruct responses to climate change (Lynn et al. 2013, Whyte 2013). Adaptation is often hindered by lack of available funding. Tribes often face exclusion from some funding sources reserved for states or, when eligible, must compete with state and local entities for limited funding. Relationships between tribes and nontribal agencies may not be conducive to climate adaptation planning and management (Shearer 2012), or agencies may lack the frameworks necessary to address certain issues (Maldonado et al. 2013).

Whyte (2013: 4–5) described how institutions can strengthen tribal adaptation, including internal and external adaptation planning, inclusive research, adaptation funding, networking, and intergovernmental negotiation, and how these things can be hindered by federal, state, and local political contexts. Such institutions exist within a political context and experience opportunity and constraint based on relationships with other institutions, such as laws, regulations, funds, judicial processes, spending decisions, bureaucrats, and constituencies. To maintain legitimacy, funding, and federal partnerships, these institutions must successfully navigate this confusing political and institutional context (Whyte 2013).

Throughout the literature are references to solutions and best practices that aim to remove barriers to tribal adaptation to climate change. Cochran et al. (2013) and Whyte (2013) both set out to establish best practices created through relationships based on justice. Cochran et al. (2013) suggested a multipronged approach to facilitate the inclusion of indigenous peoples in the development of climate-change solutions. This approach includes creating an environment in which multiple ways of knowing are respected, directly assisting communities in achieving their adaptation goals, promoting partnerships that create effective solutions from Western and indigenous perspectives, and finally, sharing climate solutions though regional and international networks. Whyte (2013) offered a justice framework to guide nontribal professionals working with tribes on issues related to adaptation. This "justice forward" approach emphasizes the responsibility of nontribal actors working with tribes to challenge the political obstructions that limit tribal adaptation. These nontribal actors can influence the institutional contexts where they work by strengthening government-to-government relationships, honoring trust responsibilities, integrating tribal and nontribal sciences, and increasing multiparty governance.

Traditional knowledges and adaptation—
Traditional knowledges affect how indigenous communities understand climate-change impacts and develop adaptation strategies (Chief et al. 2014). Traditional knowledges can make substantial contributions to the assessment of climate-change impacts and identification of potential solutions for adaptation (Alexander et al. 2011, Burkett 2012). Traditional knowledges have enabled indigenous populations to adapt to environmental changes for thousands of years and can inform climate action by recognizing changes, contributing to adaptation strategies, and implementing sustainable land management practices (Chief et al. 2013, Norgaard 2014, Parrotta and Agnoletti 2012). Traditional knowledges are community-based and therefore can produce adaptation strategies that are trusted by community members (Werkheiser 2015). The ability of indigenous peoples to use traditional knowledges to guide adaptation in the context of climate change is documented in the UNESCO and UN publication, Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation (Nakashima et al. 2012).

Differences between indigenous and Western worldviews mean that incorporating the two into a single framework can be problematic. In academic and indigenous communities, there are some concerns about attempts to merge indigenous and Western worldviews. Some argue that, based on differences, these worldviews cannot be merged, but rather one must recognize that each way of knowing can inform solutions (Cochran et al. 2013, Huntington and Watson 2012).

> A Western science emphasis on facts and an indigenous emphasis on relationships to spiritual and biophysical components indicate important but distinct contributions that each knowledge system can make (Cochran et al. 2013: 557).

Conversely, many consider traditional knowledges as complementary to Western science because the emphasis of traditional knowledges on relationships between human and non-humans provides an ethical framework for adaptation plans (Cochran et al. 2013, Huntington and Watson 2012). This point is illustrated by a 2013 observation by Terry Williams, Treaty Rights Office Commissioner for the Tulalip Tribes Natural Resource Department (Wall 2013):

> Why do we have to do this? Well, because it's in your teachings. We were taught that we're the caretakers of the land. The U.S. took it away, but it's still our land. I tell our people that if nothing else we can set the example, a bar that people will recognize. Through our history we've maintained a high moral standard. We didn't need contracts; we knew what the rules were, and we stood by them. We are the compass.

Leclerc et al. (2013) showed how cultural knowledge helps farmers perceive and remember past climate variations, taking into consideration the specificity of the contexts in which extreme climatic events were experienced. The integration of indigenous and scientific climate knowledge could contribute to the development of drought monitoring that considers both climatic and contextual data (Leclerc et al. 2013). In 2008, the United Nations Permanent Forum on Indigenous Issues encouraged indigenous groups to form the Indigenous Peoples' Biocultural Climate Change Assessment Initiative with hopes of strengthening the role of traditional knowledges in developing solutions to climate change (IPCC 2012). The IPCC has also acknowledged the value of traditional knowledges in climate change efforts. According to its 2014 Climate Change Synthesis Report:

> Indigenous, local and traditional knowledge systems and practices, including indigenous peoples' holistic view of community and environment, are a major resource for adapting to climate change, but these have not been used consistently in existing adaptation efforts. Integrating such forms of knowledge with existing practices increases the effectiveness of adaptation [IPCC 2014: 19].

Despite the benefits associated with bridging traditional knowledges within climate initiatives, indigenous peoples face potential risks in the sharing of traditional knowledges with non-indigenous entities. Williams and Hardison (2013) described

the risks that traditional knowledges may be exploited, or misused, and the incompatibility of traditional knowledges and the legal construction of copyrights, contracts, and licensure. They assert that "once traditional knowledge is shared outside of a community, it enters alien social and legal contexts." They argued for the creation of governance mechanisms and guiding principles for knowledge sharing based on justice. Traditional knowledges should be viewed as a sovereign property with its own laws determined by knowledge holders and knowledge "sharing should be based on free, prior, and informed consent and mutually agreed terms based on equal standing" (Williams and Hardison 2013; see also Brewer and Kronk Warner 2015).

In response to a call by the Department of the Interior Advisory Committee on Climate Change and Natural Resource Sciences to increase understanding about the role of, and protections for, traditional knowledges in climate-change initiatives, a group of indigenous and nonindigenous scholars, leaders, and researchers developed the *Guidelines for Considering Traditional Knowledges in Climate Change Initiatives*. These guidelines explore the significance of traditional knowledges in relation to climate change, as well as the potential risks to indigenous peoples in sharing traditional knowledges in federal and other nonindigenous climate-change initiatives (CTKW 2014). The guidelines can be used by indigenous peoples and by organizations such as state, regional, and federal agencies or other entities involved in climate-related initiatives, and are designed for (1) indigenous peoples and holders of traditional knowledges (TKs) to ensure that TKs are protected in future collaborations, (2) agencies and researchers wanting to secure access to and use of TKs, and (3) individuals reviewing grant proposals that incorporate TKs. These guidelines establish opportunities for indigenous and nonindigenous partners to combine traditional knowledges and Western science on culturally appropriate, tribally guided initiatives (CTKW 2014).

Tribal adaptation plans—
Many tribes and indigenous communities are on the forefront of climate-change adaptation and are actively identifying and addressing climate impacts (Halofsky et al. 2015). A small, but growing, number of tribal governments are developing adaptation plans, with some in the early stages of implementation. This synthesis identified 27 tribal climate-change adaptation plans for tribes in the United States (ITEP 2015, PNW Tribal Climate Change Project 2015). However, this list may not be complete and some plans may be in development. Regionally, most of these plans are found in Alaska (66 percent) and the Northwest (19 percent), with the remaining from the Southeast (7 percent), Northeast (4 percent), and

Midwest (4 percent). Many of these adaptation plans use collaborative approaches that bring together climate data and projections with traditional knowledges (Brubaker et al. 2011a, Peterson et al. 2014). For many tribes, adaptation is understood as a process rather than an outcome, and adaptation plans are intended to be working documents (CSKT 2013, Maldonado 2014b). Many tribal adaptation plans use traditional knowledges to assess local climate impacts, identify vulnerabilities, and prioritize adaptation measures.

Most adaptation plans begin with an introduction to the tribe. This often includes a discussion of tribal lands, history, culture, traditional livelihoods, and demographics. This introduction provides the context for understanding climate impacts on tribal ways of life. Tribal adaptation planning incorporates the traditional knowledges of community members and plans often highlight the importance of traditional knowledges in adaptation strategies.

> As is our practice, we look ahead to prepare for coming challenges and apply the values taught by our ancestors (CSKT 2013).

> …[T]he need to have an ethical response that respects and preserves the sensitive nature of traditional knowledge and specifies ongoing work to connect elders with youth for intergenerational sharing of spiritual and other traditional environmental knowledge (SITC 2010: 24).

The importance of community input in the identification of climate impacts and subsequent adaptation efforts is consistent throughout tribal adaptation plans. Traditional knowledges are community-based and therefore can be used to produce adaptation strategies that are trusted by community members (Werkheiser 2015).

Many tribal adaptation plans explore the impacts of climate on and vulnerabilities of areas that are culturally and economically important to tribal life. For example, the Confederated Salish and Kootenai Tribes' Climate Change Strategic Plan focuses on forestry, land, fish, wildlife, water, air, infrastructure, people, and culture. The Nez Perce Tribe's Clearwater River Subbasin Climate Change Adaptation Plan focuses on forest resources, water resources, and economic impacts (Clark and Harris 2011). Adaptation plans also identify actions and goals for moving forward and ways of addressing impacts in the short and long term. The Swinomish Climate Change Initiative Impact Assessment Technical Report (SITC 2009) and Climate Adaptation Action Plan (SITC 2010) provide comprehensive examination of the impacts of climate change on the community, lands, and resources, as well as options, priorities, and recommendations for adaptation. The Swinomish Indian

Tribal Climate Change Initiative uses indicators for environmental and community health developed by the community to determine which impacts may be most severe (SITC 2010). In 2013, the Jamestown S'Klallam Tribe used a collaborative approach to identify and address the risk the community faces from climate change. This approach used structured sector-specific meetings and a two-day workshop to allow tribal members to identify vulnerabilities and priorities.

The Alaska Native Tribal Health Consortium has developed adaptation health assessments on impacts and strategies associated with human health (Brubaker and Chavan 2011; Brubaker et al. 2010, 2011a, 2011c, 2012, 2013, 2014a, 2014b, 2014c, 2014d, 2015). These assessments use local observations and community members' traditional knowledge to identify environmental changes and help develop adaptive strategies that foster community resilience. As stated by Brubaker et al. (2014b: 1), these reports, "document issues as described by the local people and interpreted through the lens of public health." Other Alaska Native communities have developed assessment and adaptation plans. The village of Shaktoolik partnered with the University of Alaska's Sea Grant Program to develop a community-led adaptation plan that outlined methods, potential funding sources, and a step-by-step action plan.

The Alaska Native Tribal Health Consortium developed the Local Environmental Observer (LEO) Network, a system for sharing information on environmental impacts and community health. The LEO Network is a community-based system for surveillance of climate, environmental, and health events. The network documents and encourages communication between communities, academic institutions, and resource agencies with the goal of increasing the understanding of climate change to help develop appropriate adaptation strategies. It applies traditional knowledges, Western science, and modern technology to achieve a robust and effective environmental health surveillance system (Brubaker et al. 2013).

Other plans have a strong emphasis on regional collaborations. Nez Perce tribal land has multiple owners and managers, and therefore the Nez Perce Tribe's Clearwater River Subbasin Climate Change Adaptation Plan includes collaboration as an essential component of adaptation efforts. Similarly, the Saint Regis Mohawk Tribe brings together tribal decisionmakers and community members to identify priority resources and the cultural impacts of climate change. The Fond du Lac tribe has been working nationally with the USDA Forest Service Climate Change Response Framework and regionally with the Minnesota Landscape Committee.

Maladaptation—
Maladaptation refers to adaptation actions that increase vulnerability to climate-change impacts. According to Barnett and O'Neill (2010: 211), maladaptation is defined as:

> An action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on or increases the vulnerability of other systems, sectors, or social groups.

These actions can offer short-term benefits, but contribute to increased long-term vulnerability and limit future adaptation actions (Magnan 2014). Maladaptation can occur with adaptation efforts that have high economic, social, environmental costs. Maladaptation can increase GHG emissions, disproportionately burden vulnerable populations, reduce incentives to adapt, and create dependency (Barnett and O'Neill 2010, 2013). According to Barnett and O'Neill (2013), the risk of maladaptation increases with the cost of the action. This occurs because returns for the "winners" outweigh the consideration of losses for those populations that are marginalized or are distant spatially or temporally. Barnett and O'Neill (2013) explained that the greatest risk of maladaptation occurs with strategies that aim to reduce climate risk. Moderate risk of maladaptation occurs with strategies that aim to decrease sensitivity to climate risk. Finally, strategies least likely to be maladaptive are those that that aim to increase adaptive capacity (Barnett and O'Neill 2013).

The potential for maladaptation often occurs with top-down approaches (Barnett and O'Neill 2013) that do not include local perspectives (McNeeley 2012) and those with short-term temporal scales (Knapp and Trainor 2015). McNeeley (2012: 383) described instances of social maladaptation that occur when "internal factors of the social structure prevent appropriate, adaptive responses in the face of perturbations to the social-ecological system." This occurs when those decisionmakers with power are disconnected from, and lack understanding of, the local cultural and environmental context. McNeeley (2012) used a case study of the Koyukon Athabascans' fall moose hunt to illustrate how state and federal management strategies can threaten local subsistence needs. Knowledge gaps about weather and climate, uncertainty about the relations between moose breeding dates, climate, and regulations that place biological concerns over climate and cultural concerns, and the lag response in the regulatory process inhibit the local needs, and adaptive capacity, of Koyukon communities (McNeeley 2012). Although they were not specifically looking at instances of maladaptation in an analysis of stakeholder-defined research needs in the context of climate change, Knapp and Trainor (2015) described the marginal role nonscientific perspectives and local and tribal input have in these

perspectives. Additionally, most of these needs focused only on the temporal scale of from 1 to 5 years, with very few focusing on 5 to 10 years or beyond.

Ford et al. (2013) argued that, for Alaska Natives, the coping mechanisms regularly used to indicate high adaptive capacity or resilience might increase long-term vulnerability in three ways. As hunters adapt to changing species distribution and focus efforts in more concentrated areas, the stress on species populations may be displaced to the future. With fewer opportunities to engage in land use activities, the transfer and development of traditional knowledges are disrupted, minimizing the resources that can be used in the future. Maladaptation could also result from overspecialized adaptation responses that are well adapted to current climate variations, but susceptible to new stressors or future rapid climate change (Ford et al. 2013).

Other examples of potential maladaptation include the creation of climate refugia, a conservation strategy designed to facilitate the persistence of certain species during long-term, large-scale climate change (Keppel et al. 2015). Refugia are habitats to which species can retreat during climate and environmental changes, allowing them to adapt and persist (Keppel et al. 2015). Several conservation groups have proposed the creation of climate corridors—networks of protected lands—to provide habitat connectivity and allow for species movement (Noss 2015). The creation of more stringent regulations under new land designations would likely affect tribal practices. For example, in the Northwest, several climate corridors and related projects to connect the Coast, Klamath, and Cascade Ranges would likely affect tribal subsistence uses of refugia habitats for species of ecological and tribal value.

Mitigation

Although the impacts of climate change cannot be reversed, climate-change mitigation offers opportunity for tribes to confront the disproportionate impacts of climate change on indigenous communities, slow the rate of climate change, and reduce climate-change impacts. According to the IPCC (2007), climate-change mitigation refers to:

> Technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to climate change, mitigation means implementing policies to reduce GHG emissions and enhance sinks.

Climate change mitigation offers tribes opportunities to slow the rate of climate change and reduce climate-change impacts.

Many indigenous declarations on climate change, in the United States and internationally, strongly suggest that adaptation strategies must come hand in hand with

mitigation to generate benefits from multiple pathways. The Indigenous Peoples' Global Summit on Climate Change Anchorage Declaration (2009) states:

> 1. In order to achieve the fundamental objective of the United Nations Framework Convention on Climate Change (UNFCCC), we call upon the fifteenth meeting of the Conference of the Parties to the UNFCCC to support a binding emissions reduction target for developed countries (Annex 1) of at least 45 percent below 1990 levels by 2020 and at least 95 percent by 2050. In recognizing the root causes of climate change, participants call upon States to work towards decreasing dependency on fossil fuels. We further call for a just transition to decentralized renewable energy economies, sources and systems owned and controlled by our local communities to achieve energy security and sovereignty.

Affiliated Tribes of Northwest Indians (ATNI) resolution #09-19 states:

> ATNI affirms the trust responsibility of the United States Congress, the Bureau of Indian Affairs, the Department of the Interior, the Department of Energy, and other appropriate federal agencies to support tribal efforts with funding and other resources to deal with climate change, mitigate climate-change impacts to tribal communities, tribal lands, and tribal cultural traditions.
>
> ATNI urges the United States Congress and the President of the United States to move forward on a national, mandatory program to reduce climate-change pollution, to develop funding capacity for tribal community infrastructure needs, to address present and long-term climate change planning and implementation, and promote the development and adoption of renewable energy within a timeframe that prevents irreversible harm to public health, the economy and the environment.

The above declarations and resolutions frame climate-change mitigation in the context of tribal sovereignty. They call for federal climate mitigation policy that dramatically reduces greenhouse-gas emissions, and for programs that support tribal efforts to achieve energy self-sufficiency through renewable energy and energy efficiency (Maynard 2014). Tribes are using their unique political status to encourage the development of mitigation practices that reduce GHG emissions and translate into improved economic security for tribal communities. In 1994, tribes from the northern Great Plains created the Intertribal Council on Utility Policy (Intertribal COUP). Growing to 15 member tribes, this climate initiative works to develop mitigation planning and renewable energy development; carbon

sequestration and carbon offset portfolio development; and energy-efficient land use and building codes. Some tribes, such as the Yurok Tribe in California, the Nez Perce Tribe in Idaho, and the Round Valley Indian Tribes in California, are already involved in the carbon credit market as a way to preserve natural resources through terrestrial sequestration (Barboza 2014).

There are some federal funding opportunities for tribal mitigation efforts through the U.S. Department of the Interior, Department of Housing and Urban Development, Department of Energy, and Environmental Protection Agency. Although some of these are reserved for tribes and tribal organizations, others are available to other federal, state, and local applicants. This means that tribes must compete not only among themselves, but also with a larger, nontribal applicant pool, for limited federal mitigation support.

Although some tribes have urged the federal government to pursue renewable energy as a strategy for climate-change mitigation, not all projects are welcome (Maynard 2014). The Mystic Lake Declaration from the Native Peoples Native Homelands Climate Change Workshop II asserts:

> We challenge climate mitigation solutions to abandon false solutions to climate change that negatively impact Indigenous Peoples' rights, lands, air, oceans, forests, territories and waters (Maynard 2014: 122).

As the federal government pursues renewable energy projects on public land, some projects have the potential to negatively affect culturally important species or cultural sites. Recently, some renewable energy projects were planned or constructed on federal public land sacred to tribes (Raftery 2012, 2013). Tribes criticized the government for prioritizing energy-efficiency projects and fast-tracking project approval at the expense of federal trust responsibilities (Pico 2012, Raftery 2012, 2013). In 2010, a proposed solar power plant in the Sonoran Desert threatened ancient cultural sites and the habitat of the flat-tailed lizard, a culturally important species for the Quechan Indian Tribe. The tribe filed a lawsuit against the U.S. Department of the Interior, asserting that the federal government failed to fulfill its consultation obligation (Hsu 2010). In 2013, the Quechan Tribe filed another lawsuit against the BLM maintaining that, in the construction of the Ocotillo Wind Express wind farm, the federal government violated the Native Heritage Preservation Act. The project site contained more than 400 archaeological sites and six burial sites for multiple tribes, including the Quechan, Kumeyaay, and Cocopah (Raftery 2012, 2013). In a letter to President Obama, Viejas Band of Kumeyaay Indians Tribal Chairman Anthony Pico stated, "there is no mitigation that could compensate for its impacts to this cultural place" (Raftery 2012: 1).

Housing

Some tribes are also engaging in climate-change mitigation through sustainable construction and community development. In addition to the environmental benefits, sustainable construction reduces costs, saves energy, and enhances durability. Some examples of tribes using sustainable construction for housing include the Citizen Potawatomi Nation's structural insulated panels, the Pueblo of Isleta's lava block, and the St. Regis Mohawk Tribe's geothermal system (Lantz and Appelbaum 2013). According to the Intertribal COUP, the construction of sustainable housing is a way for tribal communities to build energy independence and strengthen economies. Intertribal COUP has been developing a program under which tribal college faculty and students build energy-efficient structures from local straw bale construction materials (Cordalis and Suagee 2008). The structures are naturally insulated, reduce the economic stress on homeowners by reducing energy demands for heating and cooling, while building them acts as a training program, teaching tribal members skills and techniques of straw bale construction.

There is often a connection between sustainable features and cultural features, and sustainability is often deeply connected to indigenious ways of life.

For tribes, there is often a connection between sustainable features and cultural features, and sustainability is often deeply connected to indigenous ways of life. As such, some tribes are reinvigorating their traditional building styles to be better suited to climate-change resilience (Lantz and Appelbaum 2013).

Tribes also have received support for sustainable construction through grants and programs offered by HUD, including the Sustainable Communities Initiative, Sustainable Construction in Indian Country Initiative, and HUD's Indian Community Development Block Grant (ICDBG) Program (HUD 2015a).

HUD Community Challenge Planning Grant—
Between 2009 and 2011, Congress funded the HUD's Sustainable Communities Initiative for regional and local planning efforts that "integrate housing and transportation decisions, and increase the capacity to improve land use and zoning to support market investments that support sustainable communities" (HUD 2015a). Of the two grants offered by the initiative, only one, the Community Challenge Planning Grant (CCPG), was available exclusively to tribes. The CCPG was designed to support efforts that "integrated housing, land use, economic and workforce development, transportation, and infrastructure investments" (HUD 2015a). This grant was extremely competitive; in 2010, HUD received more than 1,000 letters of interest and 360 proposals, and of the 45 grants awarded, only three included tribal elements.

The Oglala Lakota Nation in South Dakota was one of the 2010 CCPG awardees. The grant funded the regional sustainability planning project for the Oglala Lakota Nation, known as the Oyate Omniciyé plan. This plan is based on six livability principles: transportation, housing, economic competitiveness, existing communities, federal investment, and local values, and includes climate-change adaptation and mitigation planning. It includes a voluntary pledge to mitigate climate change and promote sustainability through the reduction of GHG emissions on the reservation. In 2011, the Hopi Tribe of Arizona was the only tribe awarded a CCPG. The tribe received $150,000, less than 1 percent of the total $95,802,000 awarded. After 2011, the program lost its congressional funding.

HUD Sustainable Construction in Indian Country Initiative and HUD Indian Community Development Block Grants Program—
Sustainable Construction in Indian Country is an initiative of HUD's Office of Policy Development and Research and Office of the Native American Program, which partners with tribal communities to promote and support the construction of sustainable technology in Indian Country. The Indian Community Development Block Grant Program (ICDBG) provides funding for federally recognized tribes and tribal organizations for the development of decent housing, suitable living environments, and economic opportunities. ICDBG is an annual program that is increasingly committed to sustainable projects and can be used to fund energy efficiency and green development for public facilities and housing rehabilitation, or to improve the community services with energy conservation (Lantz and Appelbaum 2013).

HUD National Disaster Resilience Competition—
In 2015, HUD, in collaboration with the Rockefeller Foundation, launched the National Disaster Resilience Competition (NDRC) to support community resilience. The competition awarded nearly $1 billion to "help communities recover from prior disasters and improve their ability to withstand and recover more quickly from future disasters, hazards, and shocks" (HUD 2015b: 1). The state of Louisiana was among the NDRC winners announced in January 2016. These funds include $48 million toward the resettlement of Isle de Jean Charles (IdJC) Band of Biloxi Chitimacha Choctaw. According to a statement by Chief Albert Naquin (Naquin and Peterson 2016: 1), "[t]his award will allow our tribe to design and develop a new, culturally appropriate and resilient site for our community, safely located further inland." This resettlement will become an important resource for other communities by providing a living model of cultural resilience, environmental stewardship, climate-change mitigation, sustainable economic development, and green building practices (Naquin and Peterson 2016: 1).

Renewable Energy

Some tribes are exploring the development of renewable resources on tribal lands to provide power for their communities and to provide employment opportunities for tribal members. Tribal lands are increasingly providing renewable energy, including wind and solar. Between 2002 and 2011, the U.S. Department of the Interior funded 159 tribal energy projects with $36 million (about $4 million annually). In 2013, $738,039 was awarded to nine projects with grants ranging from $30,000 to $449,117. The largest grant was awarded to the San Carlos Apache Tribe in Arizona for the establishment of an energy authority (USDI IEED 2013). Other recipients included the Blue Lake Rancheria, Ewiiaapaayp Band of Kumeyaay Indians, Hualapai Tribe, Quinault Indian Nation, Rampart Village, Seneca Nation of Indians, Spokane Tribe of Indians, and the Zuni Tribe (USDI IEED 2013).

The Intertribal COUP is leading efforts to reduce GHG emissions through tribal wind power development. According to Bob Gough, Intertribal COUP secretary, "tribes have the vast wind resources to build sustainable renewable energy economies on reservations to provide jobs and energy for their young and growing populations." Intertribal COUP also has majority ownership of NativeEnergy, a corporation that provides carbon offset, renewable energy credits, and carbon accounting software.

Federal government financial and advisory support is often necessary for a tribe to pursue energy planning and energy resource development. Various U.S. Department of Energy (USDOE) programs have provided assistance for tribal renewable energy development, including the USDOE Energy Efficiency and Renewable Energy (EERE) Tribal Energy Program (USDOE TEP 2016), the USDOE Office of Indian Energy Policy and Programs, and the National Renewable Energy Laboratory's Tribal Energy Program. These federal programs can provide tribes with a valuable "jump-start" on energy planning, and, unlike other federal policies, support tribal sovereignty by promoting tribal control over energy planning and resources (Brookshire and Kaza 2013: 1514). Many of these federal programs also provide grant funding and significant technical resources for tribes pursuing renewable energy development.

With a 2009 grant from the Tribal Energy Program, the Lummi Nation completed a Wind Energy Development Feasibility Assessment to quantify the feasibility of wind power on its reservation. The Lummi are also developing other small-scale renewable energy projects such as geothermal heat pumps and solar LED lighting. Many tribes use solar power as a renewable energy source for on-reservation structures, like houses and casinos. The Confederated Tribes of Umatilla use a wind turbine to power the Tamástslikt Cultural Institute (Flatt 2014).

Other tribes are in the process of offering solar energy to off-reservation customers. For example, the Pueblo of Jemez has dedicated 30 ac of land for a solar plant consisting of 14,580 solar panels and a transmission line. This project is projected to produce enough power to supply over 600 homes and offset over 278,876 tons of carbon dioxide (Oglala Sioux Tribe 2013).

Tribes are excluded from the federal government's Renewable Energy Production Incentives and the Renewable Electricity Production Tax Credit (PTC) programs. PTC, the federal government's primary renewable energy incentive program, offers incentives for programs such as wind, solar, geothermal, closed-loop biomass systems, open-loop biomass, landfill gas, waste incineration, and small hydropower (Skrelunas 2014). Tribes that are unable to finance renewable energy projects often partner with private businesses that finance projects on tribal lands. As tax-exempt entities, tribal governments do not benefit from PTC, and current law does not allow tribes to transfer unused credits to their private business partners. This means that private companies receive only a percentage of the tax credit, even if they are supplying all of the financing for a project. This makes it more difficult for tribes to attract major capital for utility-scale renewable energy projects (Skrelunas 2014).

Tribal governments are leading many of the renewable energy projects on tribal land. As tribal lands become increasingly attractive for energy development by nontribal entities, it is important that tribes consider the implications of large-scale energy development. It is important that tribes have the necessary policies and regulations to ensure that practices are consistent with tribal values (Brookshire and Kaza 2013).

Energy efficiency—
Tribes are also pursuing energy efficiency for its environmental benefit and as a way to help support low-income tribal members by reducing their energy costs. For some tribes, provisions for energy efficiency are included within climate-change adaptation planning. The Swinomish Climate Change Initiative includes the draft of an "Energy Efficiency and GHG Emissions Reduction Strategy." The goals of this strategy (SITC 2010: 85) are to:

- Reduce energy use by and costs to the tribal government.
- Reduce GHG emissions within the reservation to contribute to mitigation of global climate change.
- Encourage development of "green jobs."
- Encourage and develop sustainable practices for community and economic development and natural resource management.

Similarly, through a 2009 grant from the Administration for Native Americans, the Confederated Tribes of Siletz Indians Planning Department created the Siletz Tribal Energy Program (STEP) with goals to promote and increase energy efficiency and conservation of natural resources and reduce energy consumption and greenhouse gas emissions.

Tribes pursuing energy efficiency can apply for funding from the U.S. Department of Energy's Energy Efficiency and Conservation Block Grant (EECBG) program. This program funds energy efficiency and weatherization projects, including energy audits, developing energy plans, upgrading water heaters, installing solar water heaters, retrofitting windows, installing solar-powered street lights, and insulating buildings. The American Reinvestment and Recovery Act of 2009 created the EECBG program. Program funding is available to tribes, cities, communities, states, and U.S. territories. According to the USDOE (2013), of the $3.2 billion awarded, less than 2 percent ($54.8 million) was allocated to tribes.

Other potential grant opportunities offered by federal agencies such as the USDA, EPA, Department of Homeland Security, National Oceanic and Atmospheric Administration, and FEMA are available to tribes, but almost all require tribes to compete with some combination of state and local (cities, communities, townships) governments, public and private universities, nonprofits and for-profit organizations, and small businesses. Tribes are also excluded from funding resources reserved for states. For example, tribes are excluded from the DOE State Energy Program's (SEP) Competitive Financial Assistance Program. Between 2010 and 2013, the DOE awarded $51.8 million to states and territories to accelerate renewable energy and energy-efficiency programs, policies, and strategies.

The federal government's trust responsibility mandates a fiduciary duty toward tribes under certain circumstances, making tribes vulnerable to lapses in federal funding.

Tribes are largely dependent on federal funding to finance mitigation and adaptation programs. The federal government's trust responsibility to federally recognized tribes mandates a fiduciary duty toward tribes under certain circumstances. This dependence makes tribes vulnerable to changes in federal spending and economic adjustments. According to Gautam et al. (2013: 10):

> Tribal capacity to adapt to climate change may hinge largely on federal support and reduce their adaptive capacity. Federal support can buffer the impact of climate change on tribes, but any economic downturn under climatic or non-climatic stressors might influence the [Department of the Interior] budget and reduce federal support to tribes.

Conclusion

Barriers and Limitations to Addressing Current Impacts

Tribal perspectives are underrepresented in federal climate-change programs and initiatives (Gruenig et al. 2015). Tribal involvement is lacking on federal climate-change committees, working groups, and initiatives, leaving tribal perspectives and concerns absent from this federal dialogue. This disadvantages federal climate-change efforts, because tribes and indigenous peoples have valuable knowledge crucial to the development of effective climate-change solutions (Kronk Warner 2015b). For example, the President's State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience included 24 state and local leaders but only two tribal representatives (White House 2013). Many reports rely on the publication of peer-reviewed literature and do not take into account perspective of indigenous traditional knowledges and oral traditions. This means that reports often further marginalize indigenous perspectives (Maldonado et al. 2015). Tribal adaptation is largely dependent on federal funding that is vulnerable to political and economic contexts. Even with existing funding sources, tribes often lack equitable access to financial, technical, and other resources needed to adapt and mitigate climate impacts and support renewable energy, energy efficiency, and green jobs programs.

Many federal resource policies and mitigation efforts may not consider potential impacts on treaty and reserved rights, reservation lands, ancestral territories, usual and accustomed areas, or sacred sites. Tribes also experience barriers to the management of culturally important natural resources that are vital to the health of communities, economies, and cultures. Although tribal resource managers use traditional knowledges and modern technology to expertly manage resources, more than 40 federal natural resource funding programs exclude tribes. Additionally, the Bureau of Indian Affairs, which is responsible for many tribal natural resource programs, has experienced large budget decreases compared to other Department of the Interior agencies (Gruenig 2015). As climate change continues to affect indigenous communities, the historical and continued exclusion of tribal conservation efforts from federal funding has become increasingly apparent. For example, tribes do not have access to financial resources of the Land and Water Conservation Fund (LWCF) and are forced to compete for existing funding sources, like the Tribal Wildlife Grants Program, for which they are eligible. In 2013, the Indian Forest Management Assessment (IFMAT) emphasized the importance of federal funding to support tribal climate-change assessment and adaptation and called for a "more equitable distribution" (IFMAT 2013).

As erosion, flooding, sea-level rise, increasing storms, and permafrost thawing make coastlines and riverbanks increasingly unstable, several tribes in the

contiguous United States and Alaska are being forced to consider relocation, proactively working to keep their communities together and maintain cultural sovereignty with dignity. However, communities currently have limited options for relocation; there is currently no national framework to deal with the relocation of tribal communities, and forced relocation is compounded by the current lack of governance mechanisms and funds to support the communities. This intensifies community impoverishment, negative economic and health impacts, and loss of place, social networks, and culture caused by relocation (Bronen 2011: 360). According to Maldonado et al. (2013), "federal laws obstruct expanding or transferring tribal jurisdiction and few tribes have the economic means to buy new land." Coastal tribes often have limited resources, infrastructure, and ownership of land that worsens the impacts of climate change and makes relocation prohibitively costly. Tribes must deal with layers of tragedies and disasters; climate-change-related impacts are another layer being added to existing challenges (Maldonado et al. 2013, 2014a). For unrecognized and state-recognized tribes, like those in coastal Louisiana, lack of federal recognition causes additional institutional barriers with these tribes largely ineligible for federal support, funding, and grants.

Solutions and Best Practices

Increasing indigenous participation in climate-change initiatives is one potential solution for increasing the resilience of indigenous communities. Indigenous perspectives and traditional knowledges must guide climate-change assessment and adaptation to develop culturally appropriate strategies. In cases in which indigenous communities decide they are no longer able to stay in place, relocation must be community-directed and based on a human-rights framework (Bronen 2013). Because climate-change vulnerability is a product of historical and ongoing social inequality (Marino 2015), it is important that tribes and indigenous communities facing relocation have access to lands of their choosing that allow them to continue traditional practices. The perspectives and knowledges of indigenous communities serve as an invaluable source of knowledge for climate-change adaptation and mitigation strategies nationwide because of tribes' demonstrated capacity for adaptation (Kronk Warner 2015b). One avenue for increased indigenous participation is the National Climate Assessment (NCA) process and Intergovernmental Panel on Climate Change.

The Third National Climate Assessment (NCA3) included a chapter on the impacts of climate change on indigenous populations. However, with the limited number and diversity of indigenous communities covered and the limitation in chapter length, the report captured only a snapshot of the breadth of climate-change impacts and solutions. Publications like the NCA are often used to formulate policy

proposals related to climate change, but the lack of knowledge about climate-change impacts on indigenous peoples leaves indigenous communities in a disadvantaged position. Although NCA3 began to address these knowledge gaps, future assessments need additional data to comprehensively and sensitively describe indigenous issues (Maldonado et al. 2015). According to Maldonado et al. (2015: 2), the NCA process can be made more inclusive and findings more comprehensive through the:

1. Inclusion and integration of Indigenous perspectives within other sectors of climate assessment reports.
2. Creation of focused chapters on indigenous issues in all regional climate assessments.
3. Publication of special reports on indigenous issues.

These changes would provide opportunities for the inclusion of more indigenous perspectives and voices.

According to Maldonado et al. (2015), tribal climate-change workshops and working groups may be a valuable way to facilitate indigenous participation the NCA. Prior to NCA3, several tribal climate-change workshops were used to gather input and gain in-depth understandings of indigenous concerns with climate change. Workshops resulted in reports from coastal Louisiana tribes (CLTC 2012), Great Lakes tribes (College of Menominee Nations 2011), Alaska Native communities, Great Plains tribes (Riley et al. 2012), and the Pacific Islands (Souza and Tanimoto 2012).

> The workshops helped participants and the technical input team realize the need to consider and address not only the impacts of climate change on resources that many Indigenous communities depend upon and are deeply connected to, but to also acknowledge and highlight the grave risk climate change poses to entire cultures and ways of life. Indigenous communities themselves often hold the knowledge that can help us navigate towards a more sustainable path [Maldonado et al. 2015: 4].

There are additional tribal climate-change working groups, such as Rising Voices, First Stewards, Indigenous People's Climate Change Working Group, Native Peoples—Native Homelands, and others, that bring together communities of indigenous and nonindigenous leaders, scientists, academics, students, activists, and resource managers from across the United States. Working groups encourage knowledge sharing and discussion of climate-change impacts, needs, and strategies for adaptation and mitigation. Maldonado et al. (2015) suggested that these networks be included in future technical inputs to ensure that indigenous issues are not separated from governance structures and assessments, research agendas, and plans

Tribal climate-change working groups bring indigenous and non indigenous leaders, scientists, academics, students, activists, and resource managers together to share knowledge and to discuss impacts, needs, and strategies for adaptation and mitigation.

to address climate change. It is important that these networks are empowered in the process and receive the same consideration as climate scientists, and that participation fosters effective partnerships that support adaptation actions.

An additional avenue to increase indigenous resilience to climate change is to increase federal support for tribal communities as they prepare for climate change. According to the 2014 President's State, Local, and Tribal Leaders Task Force, resilience can be strengthened by tribal participation in all federal climate-change programs and by ensuring tribal access to data, funding, education, long-term natural resource planning, water safety and security, housing infrastructure, and food and energy security. Gruenig et al. (2015) offered a set of policy principles addressing these recommendations. The principles focus on ensuring that federally recognized tribes and other indigenous peoples and communities are full participants in assessing and addressing the problems of climate change through federal committees, a high-level task force, and federal and international climate-change initiatives; that indigenous peoples have direct, open access to resources and climate-change programs; that tribes are made eligible for existing and future federal natural resource funding programs for which states are eligible but from which tribes are currently, or might be, excluded. The principles also focus on the need for indigenous traditional knowledges, with the free, prior, and informed consent of indigenous peoples, to be acknowledged, respected, and promoted in federal policies and programs related to climate change (Gruenig et al. 2015: 3). These principles are included in 2015 resolutions by the National Congress of American Indians and the Affiliated Tribes of Northwest Indians.

Areas for Further Research

Literature discussing the impacts of climate change on American Indians and Alaska Natives has increased in the past few years. However, there are unexplored areas for future research. Although Maldonado (2013, 2014a, 2014b) has written on the subject, there remains little research exploring the impacts of climate change on state-recognized and unrecognized tribes. And although tribal vulnerability assessments and adaptation plans provide great examples of current impacts experienced by tribes, many of these impacts are absent within the peer-reviewed literature.

One of the most commonly cited climate-change impacts experienced by tribes that is mentioned in the literature is the movement of culturally important species off of reservations or trust lands. Although many cite this as a violation of treaties

that protect hunting and fishing rights, few documented examples exist to support these claims. Future tribally led research could document cases of species migration. Such research would be an important legal tool for tribes in the modernization of treaty rights. Future tribally led research should also explore phenology and the decoupling of species migration and seasonal shifts, and use traditional knowledge to explore soil-related climate impacts. The Guidelines for Considering Traditional Knowledge in Climate Change Initiatives (CTKW 2014) should be used to ensure that future research is tribally led or conduced with direct tribal engagement and the free, prior, and informed consent of tribes. For tribes to maintain control over traditional knowledges, it is important that data collected through tribal research partnerships that use federal funding are not accessible to the public through the federal Freedom of Information Act. Future research is also needed to examine the extent of tribal involvement with climate science centers as well as the extent to which federally funded climate-change research initiatives understand, and enact, their legal responsibility to tribes. The majority of literature on climate change and indigenous peoples focuses on tribes and indigenous communities in the Northwest and Southwest United States. Future research must work to include the perspectives of indigenous communities in other parts of the United States.

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Literature Cited

Abate, R.S.; Kronk Warner, E.A. 2013. Commonality among unique indigenous communities: an introduction to climate change and its impacts on indigenous peoples. In: Abate, R.S.; Kronk Warner, E.A., eds. Climate change and indigenous peoples: the search for legal remedies. Northampton, MA: Edward Elgar Publishing: 3–18.

Adger, W.N.; Agrawala, S.; Mirza, M.M.Q.; Conde, C.; O'Brien, K.; Pulhin, J.; Pulwarty, R.; Smit, B.; Takahashi, K. 2007. Assessment of adaptation practices, options, constraints and capacity. In: Parry, M.L.; Canziani, O.F.; Palutikof, J.P.; van der Linden, P.J.; Hanson, C.E., eds. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press: 717–743. Chapter 17.

Akers, D.L. 1999. Removing the heart of the Choctaw people: Indian "removal" from a native perspective. American Indian Culture and Research Journal. 23: 63–76.

Alessa, L. (Na'ia); Kliskey, A. (Anaru); Busey, R.; Hinzman, L.; White, D. 2008. Freshwater vulnerabilities and resilience on the Seward Peninsula: integrating multiple dimensions of landscape change. Global Environmental Change. 18(2): 256–270.

Alexander, C.; Bynum, N.; Johnson, E.; King, U.; Mustonen, T.; Neofotis, P.; Oettlé, N.; Rosenzweig, C.; Sakakibara, C.; Shadrin, V.; Vicarelli, M.; Waterhouse, J.; Weeks, B. 2011. Linking indigenous and scientific knowledge of climate change. BioScience. 61(6): 477–484.

Allen, M. 1989. Native American control of tribal natural resource development in the context of the federal trust and tribal self-determination. Boston College Environmental Affairs Law Review. 16: 857–895.

Allison, M.T.; Rivers, P.A.; Fottler, M.D. 2007. Future public health delivery models for Native American tribes. Public Health. 121(4): 296–307.

Anderson, K. 2005. Tending the wild: Native American knowledge and the management of California's natural resources. Berkeley, CA: University of California Press. 558 p.

Anthony, R. 2013. Animistic pragmatism and native ways of knowing: adaptive strategies for overcoming the struggle for food in the sub-Arctic. International Journal of Circumpolar Health. 72: 811–817.

Arizona v. California, 373 U.S. 546 (1963).

Armitage, P.; Kilburn, S. 2015. Conduct of traditional knowledge research—a reference guide. Whitehorse, YT: Wildlife Management Advisory Council (North Slope). 97 p. http://www.wmacns.ca/pdfs/401_ConductOfTraditionalKnowledge_Sept14_fnl_WEB.pdf. (3 May 2016).

Arquette, M.; Cole, M.; Cook, K.; LaFrance, B.; Peters, M.; Ranson, J.; Sargent, E.; Smoke, V.; Stairs, A. 2002. Holistic risk-based environmental decision making: a Native perspective. Environmental Health Perspectives. 11: 259–264**.**

Altizer, S.; Ostfeld, R.S.; Johnson, P.T.; Kutz, S.; Harvell, C.D. 2013. Climate change and infectious diseases: from evidence to a predictive framework. Science. 341: 514–519.

Bachman, R.; Zaykowski, H.; Kallmyer, R.; Poteyeva, M.; Lanier, C. 2008. Violence against American Indian and Alaska Native women and the criminal justice response: what is known. Unpublished report. On file with: U.S. Department of Justice. http://www.ncjrs.gov/pdffiles1/nij/grants/223691.pdf. (19 January 2016).

Barboza, T. 2014. Yurok tribe hopes California's cap-and-trade can save a way of life. Los Angeles Times. May 20. http://www.latimes.com/science/la-me-carbon-forest-20141216-story.html. (19 January 2016).

Barnett, J.; O'Neill, S.J. 2013. Minimising the risk of maladaptation. In: Palutikof, J.; Boulter, S.L.; Ash, A.J.; Smith, M.S.; Parry, M.; Waschka, M.; Guitart, D., eds. Climate Adaptation Futures. Oxford, United Kingdom: John Wiley & Sons: 87–93.

Barrera-Bassols, N.; Zinck, J.A.; Van Ranst, E. 2006. Symbolism, knowledge and management of soil and land resources in indigenous communities: ethnopedology at global, regional and local scales. Catena. 65(2): 118–137.

Bartrop, P.R. 2007. Episodes from the genocide of the Native Americans: a review essay. Genocide Studies and Prevention: An International Journal 2(2): 183–190.

Beil, Mark S. 2015. Local ecological knowledge and chronic disease in the Fort McDermitt Paiute-Shoshone Tribe. Boise, ID: Boise State University. M.A. thesis. 50 p. http://scholarworks.boisestate.edu/td/947. (19 January 2016).

Bennett, T.M.B.; Maynard, N.G.; Cochran, P.; Gough, R.; Lynn, K.; Maldonado, J.; Vogesser, G.; Wotkyns, S.; Cozzetto, K. 2014a. Indigenous peoples, lands, and resources. In: Melillo, J.M.; Richmond, T.C.; Yohe, G.W., eds. Climate change impacts in the United States. The Third National Climate Assessment. [Place of Publication Unknown]: U.S. Global Change Research Program: 297–317. Chapter 12.

Bennett, N.J.; Kadfak, A.; Dearden, P. 2014b. The future we want: taking action in Ban Talae Nok for the community, the environment and climate change. Victoria, BC: University of Victoria, Marine Protected Areas Research Group. 22 p.

Bernton, H. 2015. Snowpack drought has salmon dying in overheated rivers. Seattle Times [Online] July 25. http://www.seattletimes.com/seattle-news/environment/snowpack-drought-has-salmon-dying-in-overheated-rivers/. (24 January 2016).

Blackburn, M. 2012. Return to the Trail of Tears. Archaeology. 65(2): 53–64.

Blanchard, P. 2014. Our squirrels will have elephant ears: indigenous perspectives on climate change in the south central United States. Third annual climate change and indigenous peoples conference. Eugene, OR: University of Oregon.

Bonogofsky, A.; Jahshan, A.; Yu, H.; Cohn, D.; MacDonald, M. 2015. Undermined promise II. National Wildlife Federation, the Natural Resource Defense Council, and Western Organization of Resource Councils. http://www.underminedpromise.org/UnderminedPromiseII.pdf. (19 January 2016).

Booth, S.; Zeller, D. 2005. Mercury, food webs, and marine mammals: implications of diet and climate change for human health. Environmental Health Perspectives. 113(5): 521–526.

Brewer, J. II; Kronk Warner, E.A. 2015. Guarding against exploitation: protecting indigenous knowledge in the age of climate change. Social Science Research Network. http://ssrn.com/abstract=2567995. (19 January 2016).

Bronen, R. 2011. Climate-induced community relocations: creating an adaptive governance framework based in human rights doctrine. New York University Review of Law & Social Change. 35: 357–408.

Bronen, R. 2013. Climate-induced displacement of Alaska Native communities. Washington, DC: Brookings Institution. 25 p. http://www.brookings.edu/~/media/Research/Files/Papers/2013/1/30-arctic-alaska-bronen/30-climate-alaska-bronen-paper.pdf?la=en. (11 May 2016).

Bronen, R.; Chapin, F.S. 2013. Adaptive governance and institutional strategies for climate-induced community relocations in Alaska. Proceedings of the National Academy of Sciences of the United States of America. 110(23): 9320–9325.

Bronen, R. 2014a. Community relocations: the Arctic and South Pacific. In Martin, S.; Weerasinghe, S.; Taylor, A., eds. Humanitarian crises and migration. New York: Routledge: 221–242. Chapter 11.

Bronen, R. 2014b. Choice and necessity: relocations in the Arctic and South Pacific. Forced Migration Review. 45: 17–21.

Bronen, R. 2015a. Climate-induced community relocations: using integrated social-ecological assessments to foster adaptation and resilience. Ecology and Society. 20(3): 36.

Bronen, R. 2015b. Climate displacement: preparation and planning. In: Leckie, S.; Huggins, C., eds. Repairing domestic climate displacement: the peninsula principles. New York: Taylor and Francis: 89–110.

Bronen, R. 2015c. The Arctic is speaking truths about climate change. Is anyone listening? The Huffington Post. June 24. http://www.huffingtonpost.com/robin-bronen/the-arctic-is-speaking-truths-about-climate-change_b_7655414.html. (19 January 2016)

Brooks, N.; Adger, W.N.; Kelly, P.M. 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environmental Change. 15: 151–163.

Brookshire, D.; Kaza, N. 2013. Planning for seven generations: energy planning of American Indian tribes. Energy Policy. 62: 1506–1514.

Brown, H.E.; Comrie A.C.; Drechsler, D.M.; Barker, C.; Basu, R.; Brown, T.; Gershunov, A.; Kilpatrick, A.M.; Reisen, W.; Ruddell, D.M. 2013. Human health. In: Garfin, G.; Jardine, A.; Merideth, R.; Black, M.; LeRoy, S., eds. Assessment of climate change in the Southwest United States: a report prepared for the National Climate Assessment. Washington, DC: Island Press: 312–339.

Brown, P.; Lyson, M.; Jenkins, T. 2011. From diagnosis to social diagnosis. Social Science & Medicine. 73(6): 939–943.

Brubaker, M.; Zweifel, K.; Demir, J.; Shannon, A. 2015. Climate change in the Bering Strait region: observations and lessons from seven communities. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. 59 p. https://westernalaskalcc.org/projects/Lists/Project%20Products/Attachments/118/Climate-Change-and-Health-Effects-in-Bering-Straits-Region3-2015.pdf. (16 May 2016).

Brubaker, M.; Andrew, G.; Andrew, S.; Flensburg, S.; Skarada, J.; Drake, R. 2014a. Climate change in Levelock, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. 36 p. http://anthc.org/wp-content/uploads/2016/01/CCH_AR_042014_Climate-Change-in-Levelock.pdf. (16 May 2016).

Brubaker, M.; Bell, J.; Dingma, H.; Ahkivgak, M.; Whiteman, D.; Drake, R. 2014b. Climate change in Atqasuk, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. http://anthc.org/wp-content/uploads/2016/01/CCH_AR_072014_Climate-Change-in-Atqasuk.pdf. 38 p. (11 May 2016).

Brubaker, M.; Bell, J.; Dingman, H.; Evans, S.; Kasak, K.; Itta, M.; Drake, R. 2014c. Climate change in Nuiqsut, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. http://anthc.org/wp-content/uploads/2016/01/CCH_AR_072014_Climate-Change-in-Nuiqsut.pdf. 42 p. (11 May 2016).

Brubaker, M.; Bell, D.; Dingman, H.; Morales, R.; Tagarook, C.; Drake, R.; Ramstad, K. 2014d. Climate change in Wainwright, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. http://anthc.org/wp-content/uploads/2016/01/CCH_AR_062014_Climate-Change-in-Wainwright.pdf. 39 p. (11 May 2016).

Brubaker, M.; Flensburg, S.; Shanigan, N.; Skarada, J. 2013. Climate change in Pilot Point, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. http://anthc.org/wp-content/uploads/2016/01/CCH_AR_092013_Climate-Change-in-PilotPoint.pdf. 36 p. (11 May 2016).

Brubaker, M.; Chavan, P.; Berner, J.; Black, M.; Warren, J. 2012. Climate change in Selawik, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. http://arcticlcc.org/assets/products/ARCT2011-07/publications/Climate-Change-in-Selawik-Alaska.pdf. 39 p. (11 May 2016).

Brubaker, M.; Chavan, R. 2011. Climate change in Kiana, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. http://anthc.org/wp-content/uploads/2016/01/CCH_AR_102011_Climate-Change-in-Kiana.pdf. 36 p. (11 May 2016).

Brubaker, M.; Bell, J.; Berner, J.; Black, M.; Chavan, R.; Smith, J.; Warren, J. 2011a. Climate change in Noatak, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. http://anthc.org/wp-content/uploads/2016/01/CCH_AR_062011_Climate-Change-in-Noatak.pdf. 54 p. (11 May 2016).

Brubaker, M.; Berner, J.; Chavan, R.; Warren, J. 2011b. Climate change and health effects in northwest Alaska. Global Health Action. 4. http://www.globalhealthaction.net/index.php/gha/article/view/8445. (11 May 2016).

Brubaker, M.; Berner, J.; Bell, J.; Warren, J. 2011c. Climate change in Kivalina, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. 66 p. http://www.cidrap.umn.edu/sites/default/files/public/php/26952/Climate%20Change%20HIA%20Report_Kivalina.pdf. (11 May 2016).

Brubaker, M.; Bell, J.; Rolin, A. 2009. Climate change effects on traditional Inupiaq food cellars in Barrow, Alaska. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. 9 p. http://anthc.org/wp-content/uploads/2016/01/CCH-Bulletin-No-4-Climate-Change-Ice-Cellars-Barrow-Alaska.pdf. 9 p. (11 May 2016).

Brubaker, M.; Berner, J.; Bell, J.; Warren, J.; Rolin, A. 2010. Climate change in Point Hope, Alaska: strategies for community health. Anchorage, AK: Alaska Native Tribal Health Consortium, Center for Climate and Health. 39 p. http://www.cidrap.umn.edu/sites/default/files/public/php/26952/Climate%20Change%20HIA%20Report_Point%20Hope_0.pdf. (11 May 2016).

Brugnach, M.; Craps, M.; Dewulf, A. 2014. Including indigenous peoples in climate change mitigation: addressing issues of scale, knowledge and power. Climatic Change. 1–14. doi: 10.1007/s10584-014-1280-3.

Buckley, G.L.; Allen, L. 2011. Stories about mountaintop removal in the Appalachian coalfields. In: Morrone, M.; Buckley, G.L., eds. Mountains of injustice: social and environmental justice in Appalachia. Athens, OH: Ohio University Press: 161–180. Chapter 8.

Burger, J. 2008. Environmental management: integrating ecological evaluation, remediation, restoration, natural resource damage assessment and long-term stewardship on contaminated lands. Science of the Total Environment. 400: 6–19.

Burger, J.; Gochfeld, M.; Pletnikoff, K.; Snigaroff, R.; Snigaroff, D.; Stamm, T. 2008. Ecocultural attributes: evaluating ecological degradation in terms of ecological goods and services versus subsistence and tribal values. Risk Analysis. 28: 1261–1272.

Callaway, D.; Eamer, J.; Edwardsen, E.; Jack, C.; Marcy, S.; Olrun, A.; Patkotak, M.; Rexford, D.; Whiting, A. 1999. Effects of climate change on subsistence communities in Alaska. In: Weller, G.; Anderson, P.A., eds. Assessing the consequences of climate change for Alaska and the Bering Sea Region. Fairbanks, AK: University of Alaska Fairbanks, Center for Global Change and Arctic System Research: 59–73.

Cameron, E. S. 2012. Securing indigenous politics: a critique of the vulnerability and adaptation approach to the human dimensions of climate change in the Canadian Arctic. Global Environmental Change. 22(1): 103–114.

Carothers, C.; Brown, C.; Moerlein, K.J.; López, A.; Andersen, D.; Retherford, B. 2014. Measuring perceptions of climate change in northern Alaska: pairing ethnography with cultural consensus analysis. Ecology and Society. 19(4): Art. 27.

Castrodale, L. 2015. Paralytic shellfish poisoning—Alaska, 1993–2014. State of Alaska Epidemiology Bulletin. No. 1. Anchorage, AK: Department of Health and Social Services, Division of Public Health. http://www.epi.hss.state.ak.us/bulletins/docs/b2015_01.pdf. (16 May 2016).

Caufield, C. 2015. Senate field hearing focuses on tribes and coal. Native Sun News. http://www.indianz.com/News/2015/017127.asp. (16 May 2016).

Chapin, F.S.; Trainor, S.F.; Huntington, O.; Lovecraft, A.; Zavaleta, E.; Natcher, D.C.; McGuire, A.D.; Nelson, J.L; Ray, L.; Calef, M.; Fresco, N.; Huntington, H.; Rupp, T.S.; DeWilde, L.; Naylor, R.L. 2008. Increasing wildfire in Alaska's boreal forest: pathways to potential solutions of a wicked problem. BioScience. 58(6): 531–540.

Chief, K.; Daigle, J.J; Lynn, K.; Whyte. K.P. 2014. Indigenous experiences in the U.S. with climate change and environmental stewardship in the Anthropocene. In: Sample, V.A.; Bixler, R.P., eds. 2014. Forest conservation and management in the Anthropocene: adaptation of science, policy, and practices. Proceedings. RMRS-P-71. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 161–176.

Clark, K.; Harris, J. 2011. Clearwater River subbasin (ID) climate action adaptation plan. Nez Perce Tribe Water Resources Division. Sagel, ID: Model Forestry Policy Program. 58 p. http://www.mfpp.org/wp-content/uploads/2012/03/ClearwaterRiver-Subbasin_ID_Forest-and-Water-Climate-Adaptation-Plan_2011.pdf. (16 May 2016).

Climate and Traditional Knowledges Workgroup [CTKW]. 2014. Guidelines for considering traditional knowledges in climate change initiatives. http://climatetkw.wordpress.com/. (29 April 2016).

Coastal Louisiana Tribal Communities [CLTC]. 2012. Stories of change: coastal Louisiana tribal communities' experiences of a transforming environment. Workshop report input into the National Climate Assessment. 25 p. http://data.globalchange.gov/file/075e3549-2ae2-463a-833b-c4293cee36de. (4 May 2016).

Cochran, P.; Huntington, O.H.; Pungowiyi, C.; Tom. S; Chapin, F.S.; Huntington, H.; Maynard, N.; Trainor, S. 2013. Indigenous frameworks for observing and responding to climate change in Alaska. Climatic Change. 120(3): 557–567.

College of Menominee Nation. 2011. Shifting seasons: Great Lakes tribal climate change summit report. Keshina, WI: Sustainable Development Institute. http://sustainabledevelopmentinstitute.org/wp-content/uploads/2013/01/CCSummitDraft2.pdf. (9 June 2016).

Colorado River Indian Tribes. 2009. Human and cultural resource code. http://www.crit-nsn.gov/crit_contents/ordinances/Human-and-Cultural-Research-Code.pdf. (3 May 2016).

Columbia River Inter-Tribal Fish Commission. [N.d.]. Columbia Gorge coal transport. http://www.critfc.org/advocacy/columbia-gorge-coal-transport/. (19 January 2016).

Compher, C. 2006. The nutrition transition in American Indians. Journal of Transcultural Nursing. 17(3): 217–223.

Confederated Salish and Kootenai Tribes: climate change strategic plan [CSKT]. 2013. Pablo, MT: Confederated Salish and Kootenai Tribes of the Flathead Reservation.

Cordalis, D.; Suaǵee, D.B. 2008. The effects of climate change on American Indian and Alaska Native tribes. Natural Resources & Environment. 22(3): 45–49.

Cozzetto, K.; Chief, K.; Dittmer, K.; Brubaker, M.; Gough R.; Souza, K.; Ettawageshik, F.; Wotkyns, S.; Opitz-Stapleton, S.; Duren, S.; Chaven, P. 2013a. Climate change impacts on the water resources of American Indians and Alaska Natives in the U.S. Climatic Change. 3: 569–584.

Cozzetto, K.; Chief, K.; Dittmer, K.; Brubaker, M.; Gough R.; Souza, K.; Ettawageshik, F.; Wotkyns, S.; Opitz-Stapleton, S.; Duren, S.; Chaven, P. 2013b. Supplemental material: climate change impacts on the water resources of American Indians and Alaska Natives in the U.S. Climatic Change. 120(3): 569–584.

Crippa, L.; Gordon, G. 2013. International law principles for REDD+: the rights of indigenous peoples and the obligations of REDD+ actors. Working paper. Helena, MT: Indian Law Resource Center. 28 p. http://staging.ilrc.vm-host.net/sites/default/files/2013-09%20REDD%20Principles%20ENG%20FINAL%20Ref.pdf. (16 May 2016).

Dalton, M.M.; Mote, P.W.; Snover, A.K. 2013. Climate change in the Northwest: implications for our landscapes, waters, and communities. Washington, DC: Island Press. 270 p.

Dittmann, R.H. 1994. Annual flood death statistics per state per capita for the United States and Puerto Rico during the period 1959–1991. Tech. Memorandum NWS SR-153. Albuquerque, NM: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Scientific Services Division, Southern Region. http://docs.lib.noaa.gov/noaa_documents/NWS/NWS_SR/TM_NWS_SR_153.pdf. (9 June 2016).

Dittmer, K. 2013. Changing streamflow on Columbia basin tribal lands—climate change and salmon. Climatic Change. 120: 627–641. doi:10.1007/s10584-013-0745-0.

Donatuto, J.; Satterfield, T.A.; Gregory R. 2011. Poisoning the body to nourish the soul: prioritizing health risks and impacts in a Native American community. Health, Risk, and Society 13: 103–127.

Donatuto, J.; Grossman, E.; Konovsky, J.; Grossman, S.; Campbell, L. 2014. Indigenous community health and climate change: integrating biophysical and social science indicators. Coastal Management. 42(4): 355–373. doi:10.1080/08920753.2014.923140.

Donatuto, J.; Campbell, L.; Gregory, R. [N.d]. Developing responsive indicators of indigenous community health. Manuscript in preparation. On file with: Jamie Donatuto, Swinomish Indian Tribal Community, 11404 Moorage Way, La Conner, WA 98257.

Downing, A.; Cuerrier, A. 2011. A synthesis of the impacts of climate change on the First Nations and Inuit of Canada. Indian Journal of Traditional Knowledge. 10(1): 57–70.

Doyle, J.; Redsteer, M.H.; Eggers, M.J. 2013. Exploring effects of climate change on Northern Plains American Indian health. Climatic Change. 120(3): 643–655.

Driscoll, D.L.; Sunbury, T.; Johnston, J.; Renes, S. 2013. Initial findings from the implementation of a community-based sentinel surveillance system to assess the health effects of climate change in Alaska. International Journal of Circumpolar Health. 72. doi:10.3402/ijch.v72i0.21405.

Dukes, J.S.; Pontius, J.; Orwig, D; Garnas, J.; Rodgers, V.; Brazee, N.; Cooke, B.; Theoharides, K.; Stange, E.; Harrington, R.; Ehrenfeld, J.; Gurevitch, J.; Lerdau, M.; Stinson, K.; Wick, R.; Ayres, M. 2009. Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: What can we predict? Canadian Journal of Forest Research. 39: 231–248.

Dussias, A.M. 2010. Spirit food and sovereignty: pathways for protecting indigenous peoples' subsistence rights. Cleveland State Law Review. 58(2): 273.

Earle, L. 2011. Traditional aboriginal diets and health. Prince George, BC: National Collaborating Centre for Aboriginal Health.

Ebi, K.L. 2011. Resilience to the health risks of extreme weather events in a changing climate in the United States. International Journal of Environmental Research and Public Health. 8(12): 4582–4595.

Egeland, G.; Harrison, G. 2013. Health disparities: promoting indigenous peoples' health through traditional food systems and self-determination. In: Kuhnlein, H.; Erasmus, B.; Spigelski, D.; Burlingame, B., eds. Indigenous peoples' food systems & well-being interventions and policies for healthy communities. Rome: United Nations Food and Agriculture Organization; Canada: Centre for Indigenous Peoples' Nutrition and Environment.

Emery, M.R.; Wrobel, A.; Hansen, M.H.; Dockry, M.; Moser, K.W.; Stark, K.J.; Gilbert, J.H. 2014. Using traditional ecological knowledge as a basis for targeted forest inventories: paper birch (*Betula papyrifera*) in the US Great Lakes region. Journal of Forestry. 112(2): 207–214.

Enarson, E. 2011. Does violence against women increase in disasters? http://usgdra.org/wp-content/uploads/file/Does%20VAW%20Increase-july2012%20-ee.pdf. (4 May 2016).

Erwin, M.L.; Munn, M.D. 1997. Are walleye from Lake Roosevelt contaminated with mercury? Fact Sheet FS-102-97. Tacoma, WA: U.S. Department of the Interior, Geological Survey. http://wa.water.usgs.gov/pubs/fs/fs.102-97/. (4 May 2016).

Evans-Campbell, T. 2008. Historical trauma in American Indian/Native Alaska communities: a multilevel framework for exploring impacts on individuals, families, and communities. Journal of Interpersonal Violence. 23(3): 316–338.

Executive Order 13175, 65 FR 67249, November 9, 2000. Consultation and coordination with Indian tribal governments. https://www.gpo.gov/fdsys/pkg/FR-2000-11-09/pdf/00-29003.pdf. (16 May 2016).

Ferguson, D.B.C.; Alvord, M.; Crimmins, H.M.; Redsteer M.H.; Hayes, M.; McNutt, C.; Pulwarty, R.; Svoboda, M. 2011. Drought preparedness for tribes in the Four Corners region. Tucson, AZ: Climate Assessment for the Southwest. 42 p.

Ferris, E. 2012. Protection and planned relocations in the context of climate change. Geneva, Switzerland: United Nations High Commission of Refugees, Division of International Protection.

First Stewards. 2012. First stewards symposium: coastal peoples address climate change. Washington, DC: National Museum of the American Indian. http://www7.nau.edu/itep/main/tcc/docs/tribes/tribes_FirstStewards.pdf. (4 May 2016).

Fisher, M. 2014. Native American tribe prepares for climate change with the help of a soil scientist. Soil Horizons. 55(4). doi:10.2136/sh2014-55-4-f.

Flatt, C. 2014. Renewable energy takes root in northwest Indian country. Portland, OR: Oregon Public Broadcasting. http://www.opb.org/news/article/northwest-tribes-begin-energy-projects/. (June 9, 2016).

Fleischhacker, S.; Byrd, R.R.; Ramachandran, G.; Vu, M.; Ries, A.; Bell, R.; Evenson, K. 2012. Tools for healthy tribes: improving access to healthy foods in Indian country. American Journal of Preventive Medicine. 43: S123–S129.

Ford, J.D. 2012. Indigenous health and climate change. American Journal of Public Health. 102: 1260–1266.

Ford, J.D.; Bell, T.; St-Hilaire-Gravel, D. 2010. Vulnerability of community infrastructure to climate change in Nunavut: a case study from Arctic Bay. In: Hovelsrud, G.T.; Smit, B., eds. Community adaptation and vulnerability in Arctic regions. Dordrecht, The Netherlands: Springer: 107–130.

Ford, J.D.; Berrang-Ford, L.; King, M.; Furgal, C. 2010. Vulnerability of aboriginal health systems in Canada to climate change. Global Environmental Change. 20: 668–680.

Ford, J.D.; Furgal, C. 2009. Climate change impacts, adaptation and vulnerability in the Arctic. Polar Research. 28: 1–9. doi:10.1111/j.1751-8369.2009.00103.x.

Ford, J.D.; McDowell, G.; Shirley, J.; Pitre, M.; Siewierski, R.; Gough, W.; Duerden, F.; Pearce, T.; Adams, P.; Statham, S. 2013. The dynamic multiscale nature of climate change vulnerability: an Inuit harvesting example. Annals of the Association of American Geographers. 103(5): 1193–12.11.

Ford, J.D.; Willox, A.C.; Chatwood, S.; Furgal, C.; Harper, S.; Mauro, I.; Pearce, T. 2014. Adapting to the effects of climate change on Inuit health. American Journal of Public Health. 104: e9–e17.

Frumhoff, P.C.; McCarthy, J.J.; Melillo, J.M.; Moser, S.; Wuebbles, D. 2007. Confronting climate change in the U.S. Northeast: science, impacts, and solutions. Synthesis report of the Northeast Climate Impacts Assessment. Cambridge, MA: Union of Concerned Scientists. 146 p.

Fugate, C. 2013. Changing laws for the better—recognizing tribal sovereignty. Washington, DC: U.S. Department of Homeland Security, Federal Emergency Management Agency. https://www.fema.gov/blog/2013-01-31/changing-laws-better-recognizing-tribal-sovereignty. (19 January 2016).

Garibaldi, A.; Turner, N. 2004. Cultural keystone species: implications for ecological conservation and restoration. Ecology and Society. 9: 1–18.

Galanda, G. 2010. The federal Indian consultation right: a frontline defense against tribal sovereignty incursion. Government Affairs Practice Newsletter. 2: 1–14.

Garfin, G.; Jardine, A.; Meredith, R.; Black, M.; LeRoy, S., eds. 2013. Assessment of climate change in the Southwest United States: a report prepared for the National Climate Assessment. Washington, DC: Island Press. 528 p.

Gautam, M.; Chief, K.; Smith, W. 2013. Climate change in arid lands and Native American socioeconomic vulnerability: the case of the Pyramid Lake Paiute Tribe. Climatic Change. 3: 585–599.

Gearheard, S.; Pocernich, M.; Stewart, R.; Sanguya, S.; Huntington, H. 2010. Linking Inuit knowledge and meteorological station observations to understand changing wind patterns at Clyde River, Nunavut. Climatic Change. 100: 267–294.

Georgakakos, A.; Fleming, P.; Dettinger, M.; Peters-Lidard, C.; Richmond, T.C.; Reckhow, K.; White, K.; Yates, D. 2014. Water resources. In: Melillo, J.M.; Richmond, T.C.; Yohe, G.W., eds. Climate change impacts in the United States: the third national climate assessment. Washington, DC: U.S. Global Change Research Program: 69–112. Chapter 3.

Gessner, B.D. 2008. Lack of piped water and sewage services is associated with pediatric lower respiratory tract infection in Alaska. The Journal of Pediatrics. 152: 666–670.

Gittelsohn, J.; Sharma, S. 2009. Physical, consumer, and social aspects of measuring the food environment among diverse low-income populations. American Journal of Preventive Medicine. 36: S161–S165.

Gone, J.P. 2013. Redressing First Nations historical trauma: theorizing mechanisms for indigenous culture as mental health treatment. Transcultural Psychiatry. 50(5): 683–706.

Goodman, E.C. 2000. Protecting habitat for off-reservation tribal hunting and fishing rights: tribal comanagement as a reserved right. Environmental Law. 30: 279.

Grah, O.; Beaulieu, J. 2013. The effect of climate change on glacier ablation and baseflow support in the Nooksack River basin and implications on Pacific salmonid species protection and recovery. Climatic Change. 120: 657–670.

Grossman, Z.; Parker, A.; Frank, B. 2012. Asserting native resilience: Pacific Rim indigenous nations face the climate crisis. Corvallis, OR: Oregon State University Press. 240 p.

Gruenig, B.; Lynn, K.; Voggesser, G.; Whyte, K.P. 2015. Tribal climate change principles: responding to federal policies and actions to address climate change. Unpublished report. On file with: Tribal Climate Change Project, University of Oregon. (kathy@uoregon.edu).

Halofsky, J.E.; Peterson, D.L.; Marcinkowski, K.W. 2015. Climate change adaptation in United States federal natural resource science and management agencies: a synthesis. Washington, DC: U.S. Global Change Research Program. 80 p. http://www.globalchange.gov/sites/globalchange/files/ASIWG_Synthesis_4.28.15_final.pdf. (4 May 2016).

Hanna, J.M. 2007. Native communities and climate change: protecting tribal resources as part of national climate policy. Boulder, CO: University of Colorado–Boulder, Natural Resources Law Center. 67 p.

Hansen, T. 2013. Eight tribes that are way ahead of climate-adaptation curve. Indian Country Today Media Network. http://indiancountrytodaymedianetwork.com/2013/10/15/8-tribes-are-way-ahead-climate-adaptation-curve-151763. (19 January 2016).

Harper, S.L.; Edge, V.L.; Ford, J.; Willox, A.C.; Wood, M.; IHACC Research Team; RICG; McEwen, S.A. 2015. Climate-sensitive health priorities in Nunatsiavut, Canada. BMC Public Health. 15: 605.

Harris, C. 2004. How did colonialism dispossess? Comments from an edge of empire. Annals of the Association of American Geographers. 94: 165–182.

Hatfield, J.G.; Takle, R.; Grotjahn, P.; Holden, P.; Izaurralde, R.C.; Mader, T.; Marshall, E.; Liverman, D. 2014. Ch. 6: Agriculture. In: Melillo, J.M.; Richmond, T.C.; Yohe, G.W., eds. Climate change impacts in the United States: the third national climate assessment. Washington, DC: U.S. Global Change Research Program: 150–174.

Hennessy, T.; Ritter, T.; Holman, R.; Bruden, D.; Yorita, K.; Bulkow, L.; Cheek, J.; Singleton, R.; Smith, J. 2008. The relationship between in-home water service and the risk of respiratory tract, skin, and gastrointestinal tract infections among rural Alaska Natives. American Journal of Public Health. 98: 2072–2078.

Heizer, R.F. 1972. The eighteen unratified treaties of 1851–1852 between the California Indians and the United States government. Berkeley, CA: University of California Archaeological Research Facility: 1–101.

Henkel, K.E.; Dovidio, J.F.; Gaertner, S.L. 2006. Institutional discrimination, individual racism, and Hurricane Katrina. Analyses of social issues and public policy. 6: 99–124.

Himes-Cornell, A.; Kasperski, S. 2015. Assessing climate change vulnerability in Alaska's fishing communities. Fisheries Research. 162: 1–11.

Holmes, I.; Potvin, C. 2014. Avoiding re-inventing the wheel in a people-centered approach to REDD+. Conservation Biology. 28(5). 1380–1393.

Hong, E.; Perkins, R.; Trainor, S. 2014. Thaw settlement hazard of permafrost related to climate warming in Alaska. Arctic. 67: 93–103.

Hoover, E. 2013. Cultural and health implications of fish advisories in a Native American community. Ecological processes. 2: 1–12.

Houck, O.A. 2015. The reckoning: oil and gas development in the Louisiana coastal zone. Tulane Environmental Law Journal. 28: 185–455.

Houde, N. 2007. The six faces of traditional ecological knowledge: challenges and opportunities for Canadian co-management arrangements. Ecology and Society. 12: 34.

Houser, S.; Teller, V.; MacCracken, M.; Gough, R.; Spears, P. 2001. Potential consequences of climate variability and change for native peoples and homelands in climate change impacts on the United States: the potential consequences of climate variability and change. Cambridge, United Kingdom: Cambridge University Press: 351–377.

Houston, W. 2015. Eel River salmon go blind waiting rain. Eureka Times-Standard. Oct. 27. http://www.times-standard.com/article/NJ/20151027/NEWS/151029830. (20 May 2016).

Hueffer, K.; Parkinson, A.J.; Gerlach, R.; Berner, J. 2013. Zoonotic infections in Alaska: disease prevalence, potential impact of climate change and recommended actions for earlier disease detection, research, prevention and control. International Journal of Circumpolar Health. 72.

Hummel, S.; Lake, F.K. 2015. Forest site classification for cultural plant harvest by tribal weavers can inform management. Journal of Forestry. 113: 30–39.

Huntington, H.P.; Fox, S.; Berkes, F.; Krupnik, I. 2005. The changing Arctic: indigenous perspectives. In: Arctic climate impact assessment. Cambridge, United Kingdom: Cambridge University Press: 61–98.

Huntington, H.P.; Goodstein, E.; Euskirchen, E. 2012. Towards a tipping point in responding to change: rising costs, fewer options for Arctic and global societies. Ambio. 41: 66–74.

Huntington, O.H.; Watson, A. 2012. Interdisciplinarity, native resilience, and how the riddles can teach wildlife law in an era of rapid climate change. Wicazo Sa Review. 27(2): 49–73.

Hus, T. 2010. Native Americans sue U.S. over solar power plant in desert. Los Angeles Times. November 4. http://articles.latimes.com/2010/nov/04/business/la-fi-solar-tribe-20101105. (19 January 2016).

Indian Country Today Media Network [ICTMN)]. 2015. Bakken-crude-hauling oil train explodes in North Dakota, town evacuated. http://indiancountrytodaymedianetwork.com/2015/05/07/bakken-crude-hauling-oil-train-explodes-north-dakota-town-evacuated-160282. (19 January 2016).

Indian Forest Management Assessment Team [IFMAT]. 2013. An assessment of Indian forests and forest management in the United States—final report, vol.1. Portland, OR: Intertribal Timber Council. http://www.itcnet.org/issues_projects/issues_2/forest_management/assessment.html. (9 June 2016).

Indian Health Service [IHS]. 2015. Disparities. http://www.ihs.gov/newsroom/factsheets/disparities/. (20 January 2016).

Ingram, K.; Dow, K.; Carter, L. 2012. Southeast region technical report to the National Climate Assessment. New Orleans, LA: Gulf of Mexico Climate Outreach Community of Practice: 16–18.

Institute for Tribal Environmental Professionals [ITEP]. 2012. Tribal climate change profiles. http://www7.nau.edu/itep/main/tcc/Tribes/. (20 January 2016).

Intergovernmental Panel on Climate Change [IPCC]. 2007. Climate change 2007: impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. New York: Cambridge University Press. 976 p.

Intergovernmental Panel on Climate Change [IPCC]. 2014. Climate change 2014: synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change. Core writing team: Pachauri, R.K.; Meyer, L.A., eds. Geneva, Switzerland. 151 p.

International Strategy for Disaster Reduction [ISDR]. 2009. Global assessment report on disaster risk reduction. Geneva, Switzerland: United Nations, Office for Disaster Risk Reduction. http://www.preventionweb.net/english/hyogo/gar/report/index.php?id=9413&pid:34&pif:3. (16 May 2016).

Jacob, M.M. 2013. Yakama rising: indigenous cultural revitalization, activism, and healing. Tucson, AZ: University of Arizona Press. 152 p.

Jamestown S'Klallam Tribe. 2013. Climate vulnerability assessment and adaptation plan. Sequim, WA: Jamestown S'Klallam Tribe and Adaptation International. 59 p.

Jenkins, M.L. 2015. Major forest insect and disease conditions in the United States: 2013. FS-1054. Washington, DC: U.S. Department of Agriculture, Forest Service. 44 p.

Jenkins, P.; Phillips, B. 2008. Domestic violence and hurricane Katrina. In: Willinger, B., ed. Katrina and the women of New Orleans. New Orleans, LA: Tulane University, Newcomb College Institute. 20(3): 65–69. Chapter 8.

Jenni, K.; Graves D.; Hardiman J.; Hatten, J.; Mastin, M.; Mesa, M.; Montag, J.; Nieman, T.; Voss, F.; Maule, A. 2014. Identifying stakeholder-relevant climate change impacts: a case study in the Yakima River Basin, Washington, USA. Climatic Change. 124: 371–384.

Johnson, J.S.; Nobmann, E.D.; Asay, E.; Lanier; A.P. 2009. Dietary intake of Alaska Native people in two regions and implications for health: the Alaska Native Dietary and Subsistence Food Assessment Project. International Journal of Circumpolar Health. 68.

Johnson, T.; Gray, G. 2014. Shaktoolik, Alaska: climate change adaptation for an at-risk community: adaptation plan. Fairbanks, AK: University of Alaska Fairbanks, School of Fisheries and Ocean Sciences, Alaska Sea Grant. 33 p. https://seagrant.uaf.edu/map/climate/docs/Shaktoolik-Adaptation-Plan-Final-2-27-14.pdf. (9 June 2016.)

Joyce, L.A.; Running, S.W.; Breshears, D.D.; Dale, V.H.; Malmsheimer, R.W.; Sampson, R.N.; Sohngen, B.; Woodall, C.W. 2014. Forests. In: Melillo, J.M.; Richmond, T.C.; Yohe, G.W., eds. Climate change impacts in the United States: the Third National Climate Assessment, U.S. Global Change Research Program: 175–194. Chapter 7. doi:10.7930/J0Z60KZC.

Keener, V.W.; Marra, J.J.; Finucane, M.L.; Spooner, D.; Smith, M.H., eds. 2012. Climate change and Pacific Islands: indicators and impacts. Report for the 2012 Pacific Islands Regional Climate Assessment (PIRCA). Washington, DC: Island Press. 170 p.

Keppel, G.; Mokany, K.; Wardell-Johnson, G.W.; Phillips, B.; Welbergen, J.; Reside, A. 2015. The capacity of refugia for conservation planning under climate change. Frontiers in Ecology and the Environment**.** 13: 106–112.

Kirmayer, L.J.; Gone, J.P.; Moses, J. 2014. Rethinking historical trauma. Transcultural Psychiatry. 51: 299–319.

Klein, N. 2007. The shock doctrine: the rise of disaster capitalism. New York: Metropolitan Books. 558 p.

Knapp, C.N.; Trainor, S.F. 2015. Alaskan stakeholder-defined research needs in the context of climate change. Polar Geography. 38: 42–69.

Kofinas, G.P.; Chapin, F.S.; BurnSilver, S.; Schmidt, J.I.; Fresco, N.L.; Kielland, K.; Martin, S.; Springsteen, A.; Rupp, T.S. 2010. Resilience of Athabascan subsistence systems to interior Alaska's changing climate. Canadian Journal of Forest Research. 40(7): 1347–1359.

Kolahdooz F.; Simeon D.; Ferguson G.; Sharma S. 2014. Development of a quantitative food frequency questionnaire for use among the Yup'ik people of western Alaska. PLoS ONE. 11(2): e0150317. doi:10.1371/journal.pone.0150317.

Krakoff, S. 2008. American Indians, climate change, and ethics for a warming world. Denver University Law Review. 85: 8–19.

Kronk Warner, E.A. 2015a. Everything old is new again: enforcing tribal treaty provisions to protect climate change threatened resources. University of Kansas School of Law [Working Paper]. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2652954.9. (20 January 2016).

Kronk Warner, E.A. 2015b. Tribes as innovative environmental 'laboratories'. University of Colorado Law Review. 86: 789–1095.

Kukarenko, N. 2011. Climate change effects on human health in a gender perspective: some trends in Arctic research. Global Health Action. 4. doi:10.3402/gha.v4i0.7913.

LaFontaine, P.; Callero, N.; Tillmann, P. 2012. The true cost of coal: the coal industry's threat to fish and communities in the Pacific Northwest. [Report]. Merrrifield, VA: National Wildlife Federation. https://www.nwf.org/~/media/PDFs/Global-Warming/Reports/NWF_PacificCoal_FINAL.ashx. (22 January 2016).

Lake, F.K.; Long, J.W. 2014. Fire and tribal cultural resources. In: Long, J.W.; Quinn-Davidson, L.N.; Skinner, C.N. Science synthesis to support socioecological resilience in the Sierra Nevada and southern Cascade Range. Gen. Tech. Rep. PSW-GTR-247. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 173–186. Chapter 4.2. http://www.fs.fed.us/psw/publications/documents/psw_gtr247/. (20 January 2016).

Lantz, L.; Appelbaum, L. 2013. Final report: sustainable construction in Indian country initiative. Washington, DC: U.S. Department of Housing and Urban Development, Office of Policy Development and Research. 370 p.

Larson, A.M.; Brockhaus, M.; Sunderlin, W.D.; Duchelle, A.D.; Babbon, A.; Dokken, T.; Pham, T.T.; Resosudarmo, I.A.P.; Selaya, G.; Awono, A.; Huynh, T.B. 2013. Land tenure and REDD+: the good, the bad and the ugly. Global Environmental Change. 23: 678–689.

Laska, S.; Peterson, K.; Rodrigue, C.L.; Cosse', T.; Philippe; R.; Burchett, O.; Krajeski, R. 2015. Layering of natural and human-caused disasters in the context of sea level rise coastal Louisiana communities at the edge. In: Companion, M., ed. Disaster's impact on livelihood and cultural survival. Boca Raton, FL: CRC Press: 225–238. Chapter 16.

Leclerc, C.; Mwongera, C.; Camberlin, P.; Boyard-Micheau, J. 2013. Indigenous past climate knowledge as cultural built-in object and its accuracy. Ecology and Society. 18(4): 22. http://dx.doi.org/10.5751/ ES-05896-180422.

Luber, G.K.; Knowlton, J.; Balbus, H.; Frumkin, H.; Hayden, M.; Hess, J.; McGeehin, M.; Sheats, N. 2014. Human Health. In: Melillo, J.M.; Richmond, T.C.; Yohe, G.W., eds. Climate change impacts in the United States: the third national climate assessment. Washington, DC: U.S. Global Change Research Program: 220–256. Chapter 9.

Lynn, K. 2005. Wildfire protection and tribal needs assessment: a study of the resources and needs related to wildland and structural fire protection for Pacific Northwest Tribes. Working paper. Eugene, OR: University of Oregon, Institute for a Sustainable Environment. https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/2282/Tribal_fire_assessment_2-10-05.pdf?sequence=1. (20 May 2016).

Lynn, K.; Daigle J.; Hoffman J.; Lake, F.; Michelle, N.; Ranco, D.; Viles, C.; Voggesser, G.; Williams, P. 2013. The impacts of climate change on tribal traditional foods. Climatic Change. 3: 545–556.

Lynn, K.; MacKendrick, K.; Donoghue; E.M. 2011. Social vulnerability and climate change: synthesis of literature. Gen. Tech. Rep. PNW-GTR-838. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 67 p.

Maldonado, J.K. 2014a. A multiple knowledge approach for adaptation to environmental change: lessons learned from coastal Louisiana's tribal communities. Journal of Political Ecology. 21: 62–81.

Maldonado, J.K. 2014b. Facing the rising tide: co-occurring disasters, displacement and adaptation in coastal Louisiana's tribal communities. Washington, DC: American University. 295 p. Ph.D. dissertation.

Maldonado, J.K. 2015. Everyday practices and symbolic forms of resistance: adapting to environmental change in coastal Louisiana. In: Collins, A., ed. Hazards, risks, and disasters in society: a cross-disciplinary overview, Philadelphia, PA: Elsevier: 201–216. Chapter 12.

Maldonado, J.K.; Bennett, T.M.B.; Chief, K.; Cochran, P.; Cozzetto, K.; Gough, B.; Redsteer, M.H.; Lynn, K.; Maynard, N.; Voggesser, G. 2015. Engagement with indigenous peoples and honoring traditional knowledge systems. Climatic Change. 135(1): 111–126.

Maldonado, J.K.; Pandya, R.; Colombi, B., eds. 2014. Climate change and indigenous peoples in the United States: impacts, experiences and actions. Cham, Switzerland: Springer Publishing International. 174 p.

Maldonado, J.K.; Shearer, C.; Bronen, R.; Peterson, K.; Lazrus, H. 2013. The impact of climate change on tribal communities in the US: Displacement, relocation, and human rights. Climatic Change. 3: 601–614.

Marino, E. 2012. The long history of environmental migration: assessing vulnerability construction and obstacles to successful relocation in Shishmaref, Alaska. Global Environmental Change. 22: 374–381.

Marino, E. 2015. Fierce climate, sacred ground. Fairbanks, AK: University of Alaska Press. 122 p.

Maynard, N.G., ed. 1998. "Native peoples–native homelands climate change workshop: final report: circles of wisdom. Washington, DC: U.S. Global Change Research Program. 95 p. https://downloads.globalchange.gov/nca/nca1/native.pdf. (20 May 2016).

Maynard, N.G., ed. 2014. Native peoples–native homelands climate change workshop II,final report: an indigenous response to climate change. Washington, DC: U.S. Global Change Research Program. 124 p. http://neptune.gsfc.nasa.gov/uploads/images_db/NPNH-Report-No-Blanks.pdf. (20 May 2016).

McDonald, M.J.; Muldowny, J. 1982. TVA and the dispossessed. Knoxville, TN: The University of Tennessee Press. 352 p.

McLaughlin, J.B.; Sobel, J.; Lynn, T.; Funk, E.; Middaugh, J. 2004. Botulism Type E outbreak associated with eating a beached whale, Alaska. Emerging Infectious Diseases 10. 1685–1687.

McNeeley, S.M. 2012. Examining barriers and opportunities for sustainable adaptation to climate change in Interior Alaska. Climatic Change. 111: 835–857.

McNeeley S.M.; Lazrus, H. 2014. The cultural theory of risk for climate change adaptation. Weather, Climate, and Society. 6: 506–519.

McNutt, D. 2010. Northwest tribes: meeting the challenge of climate change. Olympia, WA: The Evergreen State College, Northwest Indian Applied Research Institute. 15 p. http://academic.evergreen.edu/g/grossmaz/climatechangebooklet.pdf. (20 May 2016).

McOliver, C.A.; Camper, A.K.; Doyle, J.T.; Eggers, M.; Ford, T.; Lila, M.A.; Berner, J.; Campbell, L.; Donatuto, J. 2015. Community-based research as a mechanism to reduce environmental health disparities in American Indian and Alaska Native communities. International Journal of Environmental Research and Public Health. 12(4): 4076–4100. doi:10.3390/ijerph120404076.

Michelle, N. 2012. Uses of plant food-medicines in the Wabanaki bioregions of the Northeast; a cultural assessment of berry harvesting practices and customs. Orono, ME: University of Maine. 21.

Middleton, B.R. 2013. "Just another hoop to jump through?" Using environmental laws and processes to protect indigenous rights. Environmental Management. 52: 1057–1070.

Miles, A.S. 2005. Tribal energy resource agreements: tools for achieving energy development and tribal self-sufficiency or an abdication of federal environmental and trust responsibilities? American Indian Law Review. 30: 461–476.

Millar, C.I.; Stephenson, N.L.; Stephens, S.L. 2007. Climate change and forests of the future: managing in the face of uncertainty. Ecological Applications. 17: 2145–2151.

Miller, D.W. 2011. The taking of American Indian lands in the Southeast: a history of territorial cessions and forced relocations, 1607–1840. Jefferson, NC: McFarland and Company. 230 p.

Mimura, N.; Pulwarty, R.S.; Duc, D.M.; Elshinnawy, I.; Redsteer, M.H.; Huang, H.Q.; Nkem, J.N.; Rodriguez, R.A.S. 2014. Adaptation planning and implementation. In: Field, C.B.; Barros, V.R., Dokken, D.J.; Mach, K.J.; Mastrandrea, M.D.; Bilir, T.E.; Chatterjee, M.; Ebi, K.L.; Estrada, Y.O.; Genova, R.C.; Girma, B.; Kissel, E.S.; Levy, A.N.; MacCracken, S.; Mastrandera, P.R.; White, L.L., eds. Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge University Press: 869–898.

Mobley, C.M. 2012. World War II Aleut relocation camps in southeast Alaska. Anchorage, AK: U.S. Department of the Interior, National Park Service, Alaska Region. 215 p. https://www.nps.gov/aleu/learn/historyculture/upload/mobley-aleut-book-lo_res.pdf. (9 June 2016).

Moerlein, K.J.; Carothers, C. 2012. Total environment of change: impacts of climate change and social transitions on subsistence fisheries in northwest Alaska. Ecology and Society. 17: 10.

Mondou, D.J. 1998. The American Indian Agricultural Resources Management Act: Does the Winters water bucket have a hole in it? Drake Journal of Agricultural Law. 3: 381.

Montag, J.M.; Swan, K.; Jenni, K.; Nieman, T.; Hatten, J.; Mesa, M.; Graves, D.; Voss, F.; Mastin, M.; Hardimann, J.; Maule, A. 2014. Climate change and Yakama Nation tribal well-being. Climatic Change. 124: 385–398.

Murphy, M. 2013. Chemical infrastructures of the St. Clair River. In: Boudia, S.; Jas, N., eds. Toxicants, health and regulation since 1945. London: Pickering and Chatto: 103–115.

Nakashima, D.J.; Galloway McLean, K.; Thulstrup, H.D.; Ramos Castillo, A.; Rubis, J.T. 2012. Weathering uncertainty: traditional knowledge for climate change assessment and adaptation. Paris: United Nations Educational, Scientific, and Cultural Organization, and Darwin, Northern Territories, Australia: United Nations University. 120 p.

Nania, J.; Cozzetto, K.; Gillet, N.; Duren, S.; Tapp, A.M.; Eitner, M.; Baldwin, B. 2014. Considerations for climate change and variability adaptation on the Navajo Nation. Research paper. Boulder, CO: University of Colorado–Boulder. 204 p.

Naquin, A.W.B.; Peterson, K. 2016. Isle De Jean Charles Band of Biloxi Chitimacha Choctaw receive national disaster resilience competition award for resettlement. Press release. Isle de Jean Charles, LA: Isle de Jean Charles (IdJC) Band of Biloxi-Chitimacha-Choctaw.

Natcher, D.C.; Calef, M.; Huntington, O.; Trainor, S.; Huntington, H.P.; DeWilde, L.; Rupp, S.; Chapin, F.S. 2007. Factors contributing to the cultural and spatial variability of landscape burning by native peoples of Interior Alaska. Ecology and Society. 12: 7.

National Climate Assessment and Development Advisory Committee [NCA]. 2014. Global climate change impacts in the United States. New York: Cambridge University Press. 188 p.

National Congress of American Indians [NCAI]. 2011. Resolution #PDX-11-036: Traditional ecological knowledge and climate change. http://www.ncai.org/attachments/Resolution_MZlrscMWUDNfPdJGEJQVODCZZtiNPdZRrWVaNmDdEYTmqgYqTat_PDX-11-036_final.pdf. (20 May 2016).

National Congress of American Indians [NCAI]. 2015. Native resources. http://www.ncai.org/policy-issues/land-natural-resources/native-resources. (20 May 2016).

National Fish, Wildlife and Plants Climate Adaptation Joint Implementation Working Group [NFWPCA]. 2014. National fish, wildlife & plants climate adaptation strategy: taking action. Washington, DC: Association of Fish and Wildlife Agencies; Council on Environmental Quality; Great Lakes Indian Fish and Wildlife Commission; National Oceanic and Atmospheric Administration; U.S. Fish and Wildlife Service. http://wildlifeadaptationstrategy.gov. (22 January 2016)

Native Voices. 2015. 1838: Cherokee die on Trail of Tears. https://www.nlm.nih.gov/nativevoices/timeline/296.html. (22 January 2016).

Necefer, L.; Wong-Parodi, G.; Jaramillo, P.; Small, M.J. 2015. Energy development and Native Americans: values and beliefs about energy from the Navajo Nation. Energy Research & Social Science. 7: 1–11.

Nelson, C. 2013. The polar bear in the room: diseases of poverty in the Arctic. International Journal of Circumpolar Health. 72: 417–429.

Norgaard, K. 2004. The effects of altered diet on the health of the Karuk people. Unpublished report. On file with: Karuk Tribe of California, Department of Natural Resources Water Quality Program, 64236 2nd Ave, Happy Camp, CA 96039. http://pages.uoregon.edu/norgaard/pdf/Effects-Altered-Diet-Karuk-Norgaard-2005.pdf. (22 January 2016).

Norgaard, K. 2014. The politics of fire and the social impacts of fire exclusion on the Klamath. Humboldt Journal of Social Relations. 36: 77–101.

Northwest Indian Fisheries Commission. 2015. Drought prevents salmon from returning to hatchery. http://nwtreatytribes.org/drought-prevents-salmon-from-returning-to-hatchery/. (22 January 2016).

Northwest Indian College [NWIC]. 2013. Institutional review board manual: purpose and policies. Bellingham, WA: Northwest Indian College. http://www.nwic.edu/wp-content/uploads/2015/04/IRB-Manual-Dec-2-2013-Purpose-Policies-approved-by-Board-of-Trustees.pdf. (20 January 2016).

Norton, J.B.; Sandor, J.A. 1997. Combating desertification with indigenous agricultural technology at Zuni Pueblo, New Mexico. Arid Lands Newsletter: 41.

Noss, R. 2015. Climate change and wildlife. Conservation Northwest. http://www.conservationnw.org/what-we-do/wildlife-habitat/climate-change. (20 January 2016).

O'Connell, M.; Buchwald, D.S.; Duncan, G.E. 2011. Food access and cost in American Indian communities in Washington State. Journal of the American Dietetic Association. 111(9): 1375–1379.

Oglala Sioux Tribe. 2012. Oyate Omniciyé Oglala Lakota Plan. http://www.oglalalakotaplan.org/wp-content/uploads/2013/11/Oyate-Omniciye-Final-.pdf. (24 January 2016).

Oguamanam, C. 2004. Localizing intellectual property in the globalization epoch: the integration of indigenous knowledge. Indiana Journal of Global Legal Studies. 11(2): 135–169.

Ojima, D.; Steiner, J.; McNeeley, S.; Cozzetto, K.; Childress, A., eds. 2013. Great Plains regional technical input report. Washington, DC: Island Press. 301 p.

Oliver-Smith, A., ed. 2009. Development and dispossession: the crisis of forced displacement and resettlement. Santa Fe, NM: School for Advanced Research Press. 330 p.

Olsen, K. 2013. Digging into a dirty coal deal: a plan to ship low-quality Montana coal to China is putting vast prairie habitat critical to wildlife and Indian cultural traditions at risk. National Wildlife Federation. https://www.nwf.org/News-and-Magazines/National-Wildlife/Animals/Archives/2014/Coal-And-Wildlife.aspx. (16 May 2016)

Ortman, W. 2010. Sioux reservation struggling after winter storms. Boston Globe. October 1. http://archive.boston.com/news/nation/articles/2010/02/01/sioux_reservation_struggling_after_winter_storms/. (9 June 2016.)

Osborn, R.P. 2012. Climate change and the Columbia River Treaty. Washington Journal of Environmental Law & Policy. 2: 75–123.

Oxley, M. 2015. Review of the Sendai Framework for Disaster Risk Reduction 2015–2030. [Place of Publication Unknown]: Global Network for Civil Society Organizations for Disaster Reduction.

Parker, A.; Grossman, Z.; Whitesell, E.; Stephenson, B.; Williams, T.; Hardison, P.; Ballew, L.; Burnham, B.; Bushnell, J.; Klosterman, R. 2006. Climate change and Pacific Rim indigenous nations project. Olympia, WA: The Evergreen State College, Northwest Indian Applied Research Institute. http://academic.evergreen.edu/g/grossmaz/climate.html. (4 May 2016).

Parkinson, A.; Koch, A.; Evengård, B. 2015. Infectious disease in the Arctic: a panorama in transition. In: Evengård, B. Joan Nymand Larsen, J.N.; Paasche, Ø. The new arctic. Cham, Switzerland: Springer International Publishing: 239–257. Chapter 18.

Parrotta, J.A.; Agnoletti, M. 2012. Traditional forest-related knowledge and climate change. In: Parrotta, J.; Trosper, R., eds. Traditional forest-related knowledge. Dordrecht, The Netherlands: Springer: 491–533.

Paterson, R.K.; Karjala, D.S. 2003. Looking beyond intellectual property in resolving protection of the intangible cultural heritage of indigenous peoples. Cardozo Journal of International and Comparative Law. 11: 633.

Peterson, K.; Maldonado, J. K. 2016. When adaptation is not enough: "between now and then" of community-led resettlement. In: Nuttall, M.; Crate, S., eds. Anthropology and climate change: from encounters to actions. 2nd ed. New York: Taylor & Francis. [Page range unknown].

Power Past Coal. 2015. New polling: strong majority of Washington voters oppose coal export proposals. http://www.powerpastcoal.org. (24 January 2016).

Powlson, D. 2005. Climatology: will soil amplify climate change? Nature. 433: 204–205.

Raftery M. 2012. Wind storm: tribes implore President Obama to stop Ocotillo Express wind project, save cultural resource sites. East County Magazine [Online]. http://www.eastcountymagazine.org/wind-storm-tribes-implore-president-obama-stop-ocotillo-express-wind-project-save-cultural-resource. (24 January 2016).

Raftery M. 2013. Federal judge hears Quechan Tribe's case on Ocotillo wind project harm to sacred sites. East County Magazine [Online]. http://www.eastcountymagazine.org/federal-judge-hears-quechan-tribe's-case-ocotillo-wind-project-harm-sacred-sites. (24 January 2016).

Ranco, R.; Arnett, A.; Latty, E.; Remsburg, A.; Dunckel, K.; Quigley, E.; Lilieholm, R.; Daigle, J.; Livingston, B.; Neptune, J.; Secord, T. 2012. Two Maine forest pests: a comparison of approaches to understanding threats to hemlock and ash trees in Maine. Maine Policy Review. 21(1): 76–89.

Rasmussen, K.; Hibbard, M.; Lynn, K. 2007. Wildland fire management as conservation-based development: an opportunity for reservation communities? Society and Natural Resources. 20: 497–510.

Redsteer, M.H.; Bemis, K.; Chief, K.D.; Gautam, M.; Middleton, B.R.; Tsosie, R. 2013a. Unique challenges facing Southwestern tribes: impacts, adaptation and mitigation. In: Garfin, G.; Jardine, A.; Overpeck, J., eds. Assessment of climate change in the southwest United States: a technical report prepared for the U.S. National Climate Assessment. Washington, DC: Island Press: 385–404.

Redsteer, M.H.; Bogle, R.C.; Vogel, J.M. 2011a. Monitoring and analysis of sand dune movement and growth on the Navajo Nation, southwestern United States. USGS Fact Sheet 2011–3085. Flagstaff, AZ: U.S. Department of the Interior, Geological Survey. 2 p.

Redsteer, M.H.; Kelley, K.B.; Francis, H.; Block, D. [In press]. Increasing vulnerability of the Navajo people to drought and climate change in the southwestern United States: accounts from tribal elders. In: Nakashima, D.; Rubis, J.; Krupnik, I., eds. Indigenous knowledge for climate change assessment and adaptation, part III: facing extreme events. Cambridge, United Kingdom: Cambridge University Press.

Redsteer, M.H.; Kelley, K.B.; Francis, H.; Block, D. 2011b. Disaster risk assessment case study: recent drought on the Navajo Nation, southwestern United States. In: Global Assessment Report on Disaster Risk Reduction 2011. New York: United Nations Office for Disaster Risk Reduction. 19 p.

Redsteer, M.H.; Kelley, K.B.; Francis, H.; Block, D. 2013b. Increasing vulnerability of the Navajo people to drought and climate change in the southwestern United States: accounts from tribal elders. Special report. Cambridge, United Kingdom: Cambridge University Press. http://www.preventionweb.net/english/hyogo/gar/2011/en/bgdocs/Redsteer_Kelley_Francis_&_Block_2010.pdf. (24 January 2016).

Reed, A. 2008. Class inequality, liberal bad faith, and neoliberalism: the true disaster of Katrina. In: Gunewardena, N.; Schuller, M., eds. Capitalizing on catastrophe: neoliberal strategies in disaster reconstruction. Lanham, MD: Altamira Press: 147–154.

Reid, M.G.; Hamilton, C.; Reid, S.K.; Trousdale, W.; Hill, C.; Turner, N.; Picard, C.; Lamontagne, C.; Matthews, H.D. 2014. Indigenous climate change adaptation planning using a values-focused approach: a case study with the Gitga'at Nation. Journal of Ethnobiology. 34: 401–424.

Riley, A. 2002. Indian remains, human rights: reconsidering entitlement under the Native American Graves Protection and Repatriation Act (2002). Columbia Human Rights Law Review. 34. http://ssrn.com/abstract=2449056. (24 January 2016).

Riley, R.; Blanchard, P.; Peppler, R.; Bennett, T.M.B.; Wildcat, D. 2012. Oklahoma inter-tribal meeting on climate variability and change. Meeting summary report. Norman, OK. http://www.southernclimate.org/publications/Oklahoma_Intertribal_Climate_Change_Meeting.pdf. (24 January 2016).

Rising Voices. 2014. Adaptation to climate change and variability: bringing together science and indigenous ways of knowing to create positive solutions. Workshop report. Boulder, CO: National Center for Atmospheric Research. https://www.mmm.ucar.edu/rising-voices-home. (24 January 2016).

Rivkin, I.; Trimble, J.; Lopez, E.; Johnson, S.; Orr, E.; Allen, A. 2013. Disseminating research in rural Yup'ik communities: challenges and ethical considerations in moving from discovery to intervention development. International Journal of Circumpolar Health. 72: 409–416.

Rose, J.B.; Epstein, P.R.; Lipp, E.K.; Sherman, B.H.; Bernard, S.M.; Patz, J.A. 2001. Climate variability and change in the United States: potential impacts on water-and foodborne diseases caused by microbiologic agents. Environmental Health Perspectives. 109: 211–221.

Rosen, B.H.; St. Amand, A. 2015. Field and laboratory guide to freshwater cyanobacteria harmful algal blooms for Native American and Alaska Native communities. Open-File Report 2015–1164. Reston, VA: U.S. Department of the Interior, Geological Survey. 44 p. http://dx.doi.org/10.3133/ofr20151164. (15 August 2016).

Royster, J.V. 2012. Climate change and tribal water rights: removing barriers to adaptation strategies. Tulane Environmental Law Journal. 26: 197.

Rustad, L.E.; Huntington, T.G.; Boone, R.D. 2000. Controls on soil respiration: implications for climate change. Biogeochemistry 48: 1–6.

Saint Regis Mohawk Tribe Environment Division. 2013. Climate change adaptation plan for Akwesasne. Akwesasne, NY: Saint Regis Mohawk Tribe.

Sakakibara, C. 2008. "Our home is drowning": Iñupiat storytelling and climate change in Point Hope, Alaska. Geographical Review. 98: 456–475.

Salazar, K. 2009. Secretarial Order 3289: addressing the impacts of climate change on America's water, land, and other natural and cultural resources. Washington, DC: U.S. Department of the Interior. http://www.doi.gov//whatwedo/climate/strategy/index.cfm. (24 January 2016).

Schaefer, K.; Lantuit, H.; Romanovsky, V.E.; Schuur, E.A.G. **2012.** Policy implications of warming permafrost. Nairobi, Kenya: United Nations Environment Program. 30 p.

Schauss, A.G. 2010. Emerging knowledge of the bioactivity of foods in the diets of indigenous North Americans. In: Watson, R.R.; Preedy, V.R., eds. Bioactive foods in promoting health—fruits and vegetables. New York: Academic Press: 71–84.

Schell, L.M.; Gallo, M.V. 2012. Overweight and obesity among North American Indian infants, children, and youth. American Journal of Human Biology. 24(3): 302–313.

Schlosberg, D.; Carruthers, D. 2010. Indigenous struggles, environmental justice, and community capabilities. Global Environmental Politics. 10: 12–35.

Schuler, L. 2013. Modern age protection: protecting indigenous knowledge through intellectual property law. Michigan State University Journal of International Law. 21: 751, 753.

Sequoyah v. Tennessee Valley Authority. **1979.** 480 F. Supp. 608 (E.D. Tenn. 1979).

Shearer, C. 2012. The political ecology of climate adaptation assistance: Alaska Natives, displacement, and relocation. Journal of Political Ecology. 19: 174–183.

Skrelunas, T. 2014. A big step towards tribal renewable energy self-sufficiency. Grand Canyon Trust. http://www.grandcanyontrust.org/sites/default/files/na_articleTS.pdf. (24 January 2016).

Smit, B; Wandel, J. 2006. Adaptation, adaptive capacity, and vulnerability. Global Environmental Change. 16: 282–292.

Smith, L.M.; Wade, C.M.; Case, J.L.; Harwell, L.C.; Straub, K.R.; Summers, J.K. 2014. Evaluating the transferability of a US human well-being index (HWBI) framework to Native American Populations. Social Indicators Research. 124: 157–182.

Subsidiary Body for Scientific and Technological Advice [SBSTA]. 2015. Good practices and lessons learned in adaptation planning processes addressing ecosystems, human settlements, water resources and health, and in processes and structures for linking national and local adaptation planning: a synthesis of case studies. Geneva, Switzerland: United Nations Framework Convention on Climate Change. http://unfccc.int/resource/docs/2015/sbsta/eng/04.pdf. (16 May 2016).

Swinomish Indian Tribe Community [SITC]. 2009. Swinomish climate change initiative: impact assessment technical report. La Conner, WA: Swinomish Indian Tribe Community, Office of Planning and Community Development. http://www. swinomish-nsn.gov/climate_change/Docs/SITC_CC_ImpactAssessmentTechnicalReport_complete.pdf. (24 January 2016).

Swinomish Indian Tribe Community [SITC]. 2010. Swinomish climate change initiative: climate adaptation action plan. La Conner, WA: Swinomish Indian Tribal Community, Office of Planning and Community Development. http://www.swinomish.org/climate_change/Docs/SITC_CC_AdaptationActionPlan_complete.pdf. (24 January 2016).

Tanner, T.; Lewis, D.; Wrathall, D.; Bronen, R.; Cradock-Henry, N.; Huq, S.; Lawless, C.; Nawrotzki, R.; Prasad, V.; Rahman, A.; Alaniz, R.; King, K.; McNamara, K.; Nadiruzzaman, M.; Henly-Shepard, S.; Thomalla, F. 2015. Livelihood resilience in the face of climate change. Nature Climate Change. 5: 23–26.

Tennessee Valley Authority [TVA]. 1961. Floods and flood control. Technical Report No. 26. Knoxville, TN. 302 p.

Tozier de la Poterie, A.; Baudoin, M. 2015. From Yokohama to Sendai: approaches to participation in international disaster risk reduction frameworks. International Journal of Disaster Risk Science. 6(2): 128–139.

Tribal Water Working Group [TWWG]. 2012. Water in Indian country: challenges and opportunities. Albuquerque, NM: University of New Mexico]. http://uttoncenter.unm.edu/pdfs/2012White_Paper.pdf. (24 January 2016).

Tsosie, R. 2013. Climate change and indigenous peoples: comparative models of sovereignty. In: Abate R.S.; Kronk E.A., eds. Climate change and indigenous peoples: the search for legal remedies. Cheltenham, United Kingdom: Edward Elgar: 79–95.

Turner, N.J.; Clifton, H. 2009. "It's so different today": climate change and indigenous lifeways in British Columbia, Canada. Global Environmental Change. 19(2): 180–190.

Turner, N.J.; Gregory, R.; Brooks, C.; Failing, L.; Satterfield, T. 2008. From invisibility to transparency: identifying the implications. Ecology and Society. 13(2): Art. 7.

United Nations [UN]; Martínez Cobo, J.R. 1987. Study of the problem of discrimination against indigenous populations. New York: United Nations Economic and Social Council. 203 p. http://www.un.org/esa/socdev/unpfii/documents/MCS_xvii_en.pdf. (5 May 2016).

United Nations Declaration on the Rights of Indigenous Peoples[UNDRIP]. 2007. Resolution A/RES/61/295. New York: United Nations General Assembly. http://www.un-documents.net/a61r295.htm. (23 May 2016).

United Nations Framework Convention on Climate Change [FCCC]. 2014. Report on the meeting on available tools for the use of indigenous and traditional knowledge and practices for adaptation, needs of local and indigenous communities and the application of gender-sensitive approaches and tools for adaptation. Report FCCC/SBSTA/2014/INF.11. http://unfccc.int/resource/docs/2014/sbsta/eng/inf11.pdf. (24 January 2016).

U.S. Department of Defense, Army Corps of Engineers [USACE]. 2006. Alaska village erosion technical assistance program: an examination of erosion issues in the communities of Bethel, Dillingham, Kaktovik, Kivalina, Newtok, Shishmaref, and Unalakleet. [Special Report]. Kenai, AK: Alaska District. http://www.housemajority.org/coms/cli/AVETA_Report.pdf. (6 May 2016).

U.S. Department of Energy [USDOE]. 2013. Audit report: costs incurred by selected tribal energy efficiency and conservation block grant recipients. OAS-FA-13-28. Washington, DC: Office of Inspector General, Office of Audits and Inspections. http://energy.gov/sites/prod/files/2013/07/f2/OAS-RA-13-28.pdf. (9 June 2016).

U.S. Department of Housing and Urban Development [HUD]. 1996. Assessment of American Indian housing needs and programs: final report. Washington, DC: Office of Policy Development and Research.

U.S. Department of Housing and Urban Development [HUD]. 2015a. http://www.hud.gov. (January 2016).

U.S. Department of Housing and Urban Development [HUD]. 2015b. National disaster resilience competition: phase 2 fact sheet. Washington, DC. http://portal.hud.gov/hudportal/documents/huddoc?id=NDRCFactSheetFINAL.pdf. (19 May 2016).

U.S. Department of the Interior [USDI]. 2015. http://www.doi.gov.

U.S. Department of the Interior, Office of Indian Energy and Economic Development [USDI IEED]. 2013. Tribal energy development capacity grant program. http://www.indianaffairs.gov/cs/groups/public/documents/text/idc1-026611.pdf. (24 January 2016).

U.S. General Accounting Office. 2004. Villages affected by flooding and erosion have difficulty qualifying for federal assistance. GAO-04-895T. [Statement of Robert A. Robinson, Managing Director Natural Resources and Environment. Testimony Before the Committee on Appropriations, U.S. Senate]. http://www.gao.gov/assets/120/111083.pdf. (24 January 2016).

Vinyeta, K.; Lynn, K. 2013. Exploring the role of traditional ecological knowledge in climate change initiatives. Gen. Tech. Rep. PNW-GTR-879. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 37 p.

Vinyeta, K.; Powys Whyte, K.; Lynn, K. 2015. Climate change through an intersectional lens: gendered vulnerability and resilience in indigenous communities in the United States. Gen. Tech. Rep. PNW-GTR-923. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 72 p.

Voggesser, G.; Lynn, K.; Daigle, J.; Lake, F.K.; Ranco, D. 2013. Cultural impacts to tribes from climate change influences on forests. Climatic Change. 120: 615–626.

Walker, R. 2015. Swinomish tribe files lawsuit to stop Bakken crude oil trains. Indian Country Today Media Network [Online]. April 9. http://indiancountrytodaymedianetwork.com/2015/04/09/swinomish-tribe-files-lawsuit-stop-bakken-crude-oil-trains-159938. (24 January 2016).

Wall, D. 2013. Tribal climate change profile: Tulalip Tribes. Flagstaff, AZ: Northern Arizona University, Institute for Tribal Environmental Professionals. 5 p. http://www7.nau.edu/itep/main/tcc/docs/tribes/tribes_Tulalip.pdf. (19 May 2016).

Walsh, J.; Wuebbles, D.; Hayhoe, K.; Kossin, J.; Kunkel, K.; Stephens, G.; Thorne, P.; Vose, R.; Wehner, M.; Willis, J.; Anderson, D.; Doney, S.; Feely, R.; Hennon, P.; Kharin, V.; Knutson, T.; Landerer, F.; Lenton, T.; Kennedy, J.; Somerville, R. 2014. Our changing climate. In: Melillo, J.M.; Richmond, T.C.; Yohe, G.W., eds. Climate change impacts in the United States: the third national climate assessment. Washington, DC: U.S. Global Change Research Program: 19–67. Chapter 2. doi:10.7930/J0KW5CXT.

Weaver, H. 2009. The colonial context of violence: reflections on violence in the lives of Native American women. Journal of Interpersonal Violence. 24: 1552–1563.

Weerasinghe, S.; Martin, S.; Türk, V.; Riera, J.; Franck, M.; McAdam, J.; Ferris, E. 2014. Planned relocation, disasters and climate change: consolidating good practices and preparing for the future. Sanremo, Italy: United Nations High Commissioner for Refugees. 30 p. http://www.brookings.edu/~/media/research/files/papers/2014/03/14-planned-relocations-climate-change/planned-relocations-disasters-and-climate-change-report-march-2014.pdf. (18 May 2016).

Werkheiser, I. 2015. Community epistemic capacity. Social Epistemology. [Volume and Issue Number Unknown]: 1–20. http://www.academia.edu/7745499/Community_Epistemic_Capacities. http://doi.org/10.1080/02691728.2014.971911. (24 January 2016).

White House. 2013. President's state, local, and tribal leaders task force on climate preparedness and resilience. https://www.whitehouse.gov/administration/eop/ceq/initiatives/resilience/taskforce. (24 January 2016).

White House. 2015. Fact sheet: President Obama announces new investments to combat climate change and assist remote Alaskan communities. https://www.whitehouse.gov/the-press-office/2015/09/02/fact-sheet-president-obama-announces-new-investments-combat-climate. (24 January 2016).

Whitt, L. 2009. Science, colonialism, and indigenous peoples: the cultural politics of law and knowledge. Cambridge, United Kingdom: Cambridge University Press. 284 p.

Whyte, K.P. [In press]. Food justice and collective food relations. The ethics of food: an introductory textbook. Barnhill, A.; Budolfson, M.; Doggett, T., eds. Oxford, United Kingdom: Oxford University Press.

Whyte, K.P. [2016]. Indigenous peoples, climate change loss and damage, and the responsibility of settler states. East Lansing, MI: Michigan State University. 20p. https://www.academia.edu/7485990/Indigenous_Peoples_Climate_Change_Loss_and_Damage_and_the_Responsibility_of_Settler_States. (30 July 2016).

Whyte, K.P. 2013. Justice forward: tribes, climate adaptation and responsibility. Climatic Change. 3: 517–530.

Whyte, K.P. 2014. A concern about shifting interactions between indigenous and nonindigenous parties in U.S. climate adaptation contexts. Interdisciplinary Environmental Review. 15: 114–133.

Whyte, K.P; Dockry, M.; Baule, W.; Fellman, D. 2014. Supporting tribal climate change adaptation planning through community participatory strategic foresight scenario development. In: Brown, D.; Baule, W.; Briley, L.; Gibbons, E., eds. Project reports. Ann Arbor, MI: University of Michigan, Great Lakes Integrated Sciences and Assessments Center. 10 p. http://glisa.umich.edu/media/files/projectreports/GLISA_ProjRep_Strategic-Foresight.pdf. (24 January 2016).

Wildcat, D.R. 2009. Red alert! Saving the planet with indigenous knowledge. Golden, CO: Fulcrum Publishing. 128 p.

Williams, T.; Hardison, P. 2005. Global climate change: environmental change and water law. Paper presented at the law seminars international conference What is Next for Washington Water Law?

Williams, T.; Hardison, P. 2013. Culture, law, risk and governance: contexts of traditional knowledge in climate change adaptation. Climatic Change. 120: 531–544.

Willox, A.C.; Harper, S.L.; Edge, V.L.; Landman, K.; Houle, K.; Ford, J.D. 2013. The land enriches the soul: on climatic and environmental change, affect, and emotional health and well-being in Rigolet, Nunatsiavut, Canada. Emotion, Space and Society. 6: 14–24.

Willox, A.C.; Stephenson, E.; Allen, J.; Bourque, F.; Drossos, A.; Elgarøy, S.; Kral, M.J; Mauro, I.; Moses, J.; Pearce, T.; MacDonald, J.P.; Wexler, L. 2015. Examining relationships between climate change and mental health in the Circumpolar North. Regional Environmental Change. 15: 169–182.

Wilson, N.J. 2014. The politics of adaptation: subsistence livelihoods and vulnerability to climate change in the Koyukon Athabascan village of Ruby, Alaska. Human Ecology. 42: 87–101.

Wilson, N.J.; Walter, M.T.; Waterhouse, J. 2015. Indigenous knowledge of hydrologic change in the Yukon River Basin: a case study of Ruby, Alaska. ARCTIC. 68: 93–106.

Winters v. United States, [207 US 564 (1908)].

Wisner, B. 2004. Assessment of capability and vulnerability. In: Bankoff, G.; Frerks, G.; Hilhorst, D. Mapping vulnerability: disasters, development and people. London: Earthscan: 183–193.

Wood M. 2014. Tribal environmental leaders summit keynote address: tribal trustees in climate change. American Indian Law Journal. 2: 518–546.

World Intellectual Property Organization [WIPO]. 2014. Intergovernmental Committee (IGC). http://www.wipo.int/tk/en/igc/. (24 January 2016).

Yardley, W. 2015. In dispute over coalmine project, two ways of life hang in the balance. Los Angeles Times. July 21. http://www.latimes.com/nation/la-na-sej-crow-coal-20150721-story.html. (23 May 2016).

Yazzie, D.H.; Chee, C.; Darden, S.A.; Gleason, I.; Denetdale, J.N. 2012. The impact of the Navajo-Hopi Land Settlement Act of 1974 P.L. 93-531 et al. Public hearing report. Window Rock, Navajo Nation (AZ): Navajo Nation Human Rights Commission. 74 p. http://www.nnhrc.navajo-nsn.gov/docs/NewsRptResolution/070612_The_Impact_of_the_Navajo-Hopi_Land_Settlement_Act_of_1974.pdf. (20 May 2016).

Appendix: Key Terminology

Adaptation—Defined by the International Panel on Climate Change (IPCC) as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." (IPCC 2007: 869). McNeeley and Lazrus (2014) contributed to a more nuanced understanding of adaptation by noting that for adaptation actions to occur, planners and decisionmakers must have knowledge of the societal systems and cultures for whom they are working (e.g., indigenous peoples).

Adaptive capacity—The IPCC defines adaptive capacity as "the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC 2007: 869).

Climigration—The term climigration has become common in describing forced migrations in response to long-term, climate-induced environmental changes. In this synthesis, we use the definition of climigration put forth by Bronen (2008): "climigration occurs when a community is no longer sustainable exclusively because of climate-related events and permanent relocation is required to protect people." Bronen also notes that climigration cannot effectively be addressed using a natural-disaster response framework, as the impacts to people are long term and chronic.

Displacement (see "Relocation")—As discussed in this synthesis, displacement refers to a broad range of circumstances in which a population is compelled to leave their homes, whether through violence, state action (e.g. relocation), environmental change, disaster, or other traumatic events. Indigenous peoples in the United States have experienced displacement through settler-colonialism, war, removal to reservations, termination and other assimilation programs, environmental degradation, and climate change.

Indigenous—Definitions of "indigenous" and what constitutes an indigenous community differ. For the purpose of this document, we use the definition put forth by Jose R. Martínez Cobo for the United Nations. It defines indigenous communities as "those which, having a historical continuity with pre-invasion and pre-colonial societies that developed on their territories, consider themselves distinct from other sectors of the societies now prevailing on those territories, or parts of them. They form at present non-dominant sectors of society and are determined to preserve, develop and transmit to future generations their ancestral territories, and their ethnic identity, as the basis of their continued existence as peoples, in accordance with

their own cultural patterns, social institutions and legal system" (UN and Martínez Cobo 1987). When we refer to indigenous communities in the United States, we refer to peoples forming part of American Indian, Alaska Native, and Native Hawaiian populations, be they federally recognized, state-recognized, or unrecognized (see also Vinyeta and Lynn 2013).

Maladaptation—Adaptation actions that increase vulnerability to climate-change impacts. According to Barnett and O'Neill (2010: 211), maladaptation is defined as "an action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups."

Mitigation—The IPCC describes mitigation as "an anthropogenic intervention to reduce the anthropogenic forcing of the climate system; it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks." Mitigation strategies reduce actions that drive climate change (i.e., the production of greenhouse gases) (IPCC 2007: 878).

Relocation—The United Nations High Commissioner for Refugees (UNHRC) defines relocation as the movements of people that are instigated, supervised, and carried out by state authorities (Weerasinghe et al. 2014). Bronen (2015a) presented an alternative definition of relocation as the rebuilding of livelihoods, houses, public infrastructure, and social networks in another location (Bronen 2015a). Relocations can be either temporary, called evacuations, or permanent, called resettlement, and are considered a form of displacement (Weerasinghe et al. 2014).

Resilience—In the context of climate change, resilience refers to the ability of people and communities to cope with and recover from climate-change impacts. The physical, economic, sociopolitical, and cultural conditions of a person or community often intersect to define that person or community's resilience in the face of climate change. However, resilience is not static and can be strengthened or weakened as physical, economic, sociopolitical, and cultural changes unfold. Some characteristics may be a source of both vulnerability (See "Vulnerability") and resilience. For example, indigenous communities are more vulnerable to climate-change impacts because of their dependence on and deep reciprocal relationship with specific plant and animal species whose range and distribution may change with the changing climate. Simultaneously, this deep reciprocal relationship with the land results in the development of indigenous knowledge and experiences that can inform climate-change adaptation strategies and thus enhance the resilience of indigenous communities (ISDR 2009, Wildcat 2009; see also Vinyeta and Lynn 2013).

Self-determination—The United Nations Declaration of the Rights of Indigenous Peoples (UNDRIP 2007) describes self-determination, stating that UNDRIP "affirm[s] the fundamental importance of the right to self-determination of all peoples, by virtue of which they freely determine their political status and freely pursue their economic, social and cultural development." Indigenous communities, as affirmed by UNDRIP, have a right to self-determination.

Tribal sovereignty—The right of federally recognized tribes to govern themselves, define membership, protect cultural resources, control economic activity, and manage tribal land and resources. Tribal sovereignty also recognizes the existence of a government-to-government relationship between federally recognized tribes and the federal government (Galanda 2010, Goodman 2000, Redsteer et al. 2013a). Tsosie (2013) differentiated between political sovereignty and cultural sovereignty. Although political sovereignty results from federal recognition, all indigenous communities, regardless of recognition, possess cultural "self-defined" sovereignty. This means that indigenous peoples experience the right to self-determination by maintaining their ways of life and can be used to protect indigenous rights to language, religion, and culture (see also Whyte 2013, Whyte in press).

Traditional knowledges—Multiple labels have been created to describe the knowledge systems of indigenous peoples, including traditional knowledge (TK), traditional ecological knowledges, indigenous knowledge, and indigenous science. For the purposes of this synthesis, we rely on the terminology and explanation provided by the Climate and Traditional Knowledges Workgroup, who describe TKs as "[TKs are more than] individual pieces of information; this term also refers to traditional 'knowledge systems' that are deeply embedded in indigenous ways of life. [we] use the phrase "traditional knowledges" deliberately in plural form because knowledges are emergent from the symbiotic relationship of indigenous peoples and places—a nature-culture nexus. Tribes and indigenous peoples use 'knowledges' to emphasize that there are diverse forms of traditional knowledge and knowledge systems that must be recognized as unique to each tribe and knowledge holder" (CTKW 2014).

Vulnerability—In the context of climate change, vulnerability refers to a person or community's likelihood of exposure, as well as sensitivity to climate-change impacts. Smit and Wandel (2006: 286) stated, "...the vulnerability of any system (at any scale) is reflective of (or a function of) the exposure and sensitivity of that system to hazardous conditions and the ability or capacity or resilience of the system to cope, adapt or recover from the effects of those conditions." A person or community's vulnerability to climate-change impacts depends on a number of factors, including that person or community's physical, sociopolitical, and cultural resilience (See "Resilience"). Although a number of people in a given location may be exposed to the same climatic changes, physical, sociopolitical, and cultural conditions such as poverty, intersectional oppression, health limitations, lack of decisionmaking power, etc., may make some people more vulnerable to these changes and their associated impacts (ISDR 2009, Lynn et al. 2011; see also Marino 2015, Vinyeta and Lynn 2013).

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